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The United States Air Force High School Apprenticeship Program's (USAF- HSAP) purpose is to place outstanding high school students whose interests are in the areas of mathematics, engineering, and science to work in a laboratory environment. The students selected to participate in the program work in an Air Force Laboratory for a duration of 8 weeks during their summer vacation.

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VOLUME 12B
ARMSTRONG LABORATORY

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Washington, D.C.

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PREFACE

Reports in this volume are numbered consecutively beginning with number 1. Each report is paginated with the report number followed by consecutive page numbers, e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

This document is one of a set of 16 volumes describing the 1995 AFOSR Summer Research Program. The following volumes comprise the set:

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1	Program Management Report
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2A & 2B	Armstrong Laboratory
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THE EFFECT OF HYPERBARIC OXYGENATION AND HYPOBARIC EXPOSURE ON PERIPHERAL BLOOD MONONUCLEAR CELLS

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

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July, 1995

The Effect of Hyperbaric Oxygenation and Hypobaric Exposure on Peripheral Blood Mononuclear Cells

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Abstract

The proliferation of peripheral blood mononuclear cells (PBMC's) under various atmospheric stressors was studied. PBMC's were extracted from remnant blood using the density gradient provided by Histopaque solution. The cells were then exposed to conditions equivalent to 45 feet below sea level using a hyperbaric chamber, sea level as a control, and 85,000 feet above sea level using an altitude chamber. The experimental data indicated that hyperbaric oxygenation suppresses the proliferation of PBMC's, while exposure to hypobaric conditions increases cell reproduction and survival compared to the control.

THE EFFECTS OF HYPERBARIC OXYGENATION AND HYPOBARIC EXPOSURE ON PERIPHERAL BLOOD MONONUCLEAR CELLS

Karen M. Johnson

Introduction

Peripheral blood mononuclear cells (PBMC's) include T-cells, B-cells, monocytes, and macrophages. These cells are all leukocytes, or white and colorless nucleated cells of the blood (white blood cells). Some leukocytes are highly phagocytic cells with densely granular cytoplasm and complexly segmented nucleus, like monocytes and macrophages. Other leukocytes, like T-cells and B-cells, are also referred to as lymphocytes. These cells have nearly clear cytoplasm, simple or kidney-shaped nuclei, and are involved in antibody production. Each of these cells plays an important role in the immune function of the body; antibodies produced and regulated by lymphocytes are instrumental in the labeling of foreign particles, bacteria, and viruses for destruction by phagocytes. One function of white blood cells is the release of toxins in an area of damaged tissue in order to kill it and prevent the spread of infection. However; in this day and age; antibiotics, surgery, and other treatments such as hyperbaric oxygenation can kill bacteria and eliminate the need for tissue death. Therefore, decreased numbers of leukocytes in the blood of a patient with damaged tissue due to radiation, bacterial infection, or diabetic non-healing wounds can allow the tissue to be saved without endangering surrounding tissues.

Hyperbaric oxygenation (HBO) is a treatment which uses pure oxygen under pressure to maximize tissue oxygen levels. HBO is used in both emergency conditions such as decompression sickness and carbon monoxide poisoning and in clinical circumstances including osteomyelitis, radiation tissue necrosis, and compromised wounds. Many hyperbaric oxygenation patients who are treated for damaged or infected soft tissues would benefit from decreased proliferation of leukocytes in order to increase their chances of saving the tissue and decrease the need for amputation and tissue removal. Another benefit is that the occurrence of fewer lymphocytes leaves the blood system open, allowing better delivery of antibiotics to infected areas.

A measure of cell proliferation in PBMC populations when exposed to hyperbaric oxygenation shows the

effects of this treatment on the immune system. Cells exposed to the normal conditions of regular air (21% oxygen) and 1 ATA (pressure at sea-level) provide a negative control. Cells exposed to hypobaric conditions provide a positive control; this is because HBO has been shown to combat the various biological effects of high altitude exposure, as is seen in its use to treat decompression sickness ("The Bends").

Problem

The two-fold purpose of this experiment was to observe how hyperbaric oxygenation alters cell proliferation and to show that rapid decompression provides a positive control.

Methodology

To extract PBMC's from remnant blood, whole blood was diluted using phosphate buffered saline (PBS) solution. Next, in a 15 ml centrifuge tube, the blood was layered on top of a Histo-paque solution, which provided a density gradient. The tube was then centrifuged at 2,000 rpm for 15 minutes. The tube contained a top layer of blood serum with an underlying layer of PBMC's. The removed PBMC's were washed with 10 ml of PBS in a centrifuge at 800 rpm for 5 minutes. The PBMC's were then suspended in media; composed of sterile water, fetal bovine serum, penicillin, and RPMI; at a concentration between 500,000 and 1,000,000 cells per milliliter. Once the correct concentration had been reached, the cell suspension was divided into three parts and plated onto 12 well micro-titer plates. One plate was left under sterile conditions at 1 ATM of pressure. Another plate was exposed to hyperbaric oxygenation at the equivalent depth of 45 feet below sea level (66 psi) for 90 minutes. The remaining plate was placed in an altitude chamber and exposed to the equivalent of 25,000 feet above sea level for 2 minutes. It was then rapidly decompressed to the equivalent of 85,000 feet above sea level for an additional 2 minutes. After exposures, all three plates were kept in an incubator for three days. Cell concentrations were counted using a microscope and hemacytometer on the first and third days of incubation.

Results

Three experiments were done using initial cell concentrations of 500,000 cells/ml. After three days, cells exposed to rapid decompression showed the greatest proliferation and cells exposed to hyperbaric oxygenation showed the least proliferation in comparison to the control. Cell concentrations of cultures exposed to hyperbaric oxygenation averaged 90,000 cells/ml on the first day and 160,000 cells/ml on the third day. Control cell cultures

averaged concentrations of 130,000 cells/ml on the first day and 340,000 cells/ml on the third day. The increased cell proliferation in comparison to the negative control caused by exposure to rapid decompression shows altitude to be the positive control we expected it to be. The low concentrations of cells in comparison to the starting concentration can be explained by the relatively short life-time of peripheral blood cells.

Conclusion

This initial experiment has shown HBO to decrease the proliferation of leukocytes in human remnant blood. These results have potential positive ramifications for patients treated by HBO for soft tissue trauma and/or infection who would benefit from the suppression of white blood cell adhesion. However, this experiment involves only one system--a few specific types of human peripheral blood cells. This research should be repeated studying leukocytes and their relationships with surrounding cells under similar conditions, studying individual components and characteristics of peripheral blood cells under hyperbaric and hypobaric stressors, and studying the response of the human body in general. Another direction that could be taken would be to repeat the experiment using feeder cells. Feeder cells increase the life span of neutrophils by providing antioxidant protection. If the peripheral blood cells could be kept alive for longer than a few days, long term effects of varied atmospheric pressures could be better measured.

Laboratory Experience

My research experience this summer has been exciting and educational. I had the chance to work with a table-top centrifuge, hemacytometer, and bio-safety cabinet for the first time. My pipette and microscope skills were nearly perfected in the process. It was a novel experience to work in a lab where materials are laid out and measured by the teacher beforehand. This experience has truly prepared me for the real world of scientific research.

References

Knowledge gained these past eight weeks can be attributed to intensive training and assistance from the various scientists, physicians, physiologists, and other personnel on the staff at AL/AOH, especially Dr. Edward Piepmeir and Maj. George Kemper.

THE EFFECTS OF TOLUENE EXPOSURE IN HIGH NOISE ENVIRONMENTS

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THE EFFECTS OF TOLUENE EXPOSURE IN HIGH NOISE ENVIRONMENTS

Human exposure to frequent and high decibel levels of noise has long been known to cause hearing loss by damaging certain components of the auditory system. Neurotoxic chemicals, which can damage or functionally impair the central nervous system (CNS), are widely used in industry today (11). Toluene is one such neurotoxin used as a main ingredient or additive in paints, lacquers, chemicals, fuels, solvents, adhesives, and rubber products (11). Occupational use, accidental exposures, and abusive inhalation of toluene has been documented to adversely effect the auditory system as well (1,2,3,11). Research regarding toluene toxicity using experimental animals has been conducted to determine maximum safe exposure levels to humans (4,5,6,9,10,12).

Experimental rats exposed to toluene vapors exhibited excitement, visual searching, increased heart rate, and actions which researchers suggest to be hallucination behaviors (10). Research efforts on various rat species showed that toluene not only affected the rats, but affects were also noted in their auditory systems (4,5,6,9,10,12). Significant findings from these works showed that: 1) exposure sequence of toluene followed by noise accelerated and increased the amount and degree of auditory damage; 2) morphological (i.e. cytocochleograms of hair cell loss) techniques indicated that the outer hair cells in the middle and basal turns of the Organ of Corti were the predominant site of damage; and 3) decreased auditory sensitivity, noted by auditory brainstem response (ABR) audiometry, was only in the mid to high frequency range (4 -12k Hz).

In an experiment by Johnson et al (5), Sprague-Dawley male rats were exposed to either noise, toluene, or toluene followed by noise. Using ABR, these investigators found auditory sensitivity had decreased in rats exposed to toluene followed by noise more than in rats exposed to either noise or toluene alone. In a different experiment, Johnson et al (6) used diminished amplitudes of the distortion product otoacoustic emissions (DPOAEs) to localize the site of damage to the outer hair cells in the cochlea. The authors in both studies suggest that the exposure se-

quence of toluene and noise, and duration of exposure to toluene can determine the degree of hearing loss.

Pryor et al (9) conducted an experiment to determine if rats exposed to toluene showed any deficit in hearing sensitivity. Hearing sensitivity of the rats was measured using a conditioned avoidance response (CAR) to a tone-discrimination task at 4k, 8k, and 12k Hz. They found that at 4k Hz hearing sensitivity was not affected, while at 8k Hz sensitivity was slightly impaired, and at 12k Hz sensitivity was markedly impaired. It was suggested by the authors that further research be conducted to determine the potential hazards of exposure to toluene.

In yet another study, Pryor et al (10) focused on the concentration and parameters of exposure necessary to cause toluene-induced ototoxicity in rats. In this study, the investigators variably exposed rats to different concentrations of toluene via inhalation for different daily schedules (i.e. 1000-4000 parts per million (ppm) over 30-60 minutes for 8-14 hours per day). Following two weeks of exposure, the rats CAR behavioral patterns, as well as ABR testing, denoted hearing losses. The authors suggested that the exposure limits be equal to or less than the eight hour time weighted average of 200 ppm as recommended by the Occupational Safety and Health Administration (OSHA) in 1984(10). The authors concluded that problems should only occur in the event of accidental exposures which exceed recommended exposure limits.

To study ototoxicity in Sprague-Dawley rats exposed to toluene, Sullivan et al (12) used cytocochleograms of hair cell loss and ABR threshold evaluations to determine the degree and position of cochlear damage. The investigators found that there was an outer hair cell loss at the middle and basal turns on the Organ of Corti in rats that were exposed to toluene. It was also found that the rats with the greatest amount of hair cell loss had elevated ABR thresholds in the mid-frequency range (2k-8k Hz). This was the first study to find an auditory sensitivity loss in the mid-frequency range.

Researchers who conducted these studies on rats suggested that human subjects exposed to similar noise and toluene environments might show similar symptoms and reactions (4,5,6,9,10,12). Behavioral side effects and physical symptoms of accidental and self-induced toluene inhalation exposures to humans have been documented to include: fatigue, headaches,

hilarity, nausea, dizziness, motor weakness, fear, and euphoria (1). Besides it's intoxicating effects, toluene has also been found to elicit varying degrees hearing loss in exposed industrial workers (2,3,7,8,11).

A case study was done by Ehyai and Freemon (3), in 1983, on a 27 year old male who chronically sniffed glue. Initial examination of the subject was done in 1976, due to his complaints of slurred speech and increasing incoordination. The patient had testing which included a cranial nerve examination, sensory and motor examinations, and a computed tomographic (CT) scan. Results showed no significant abnormalities. Then in 1980, the subject was reassessed because of complaints of hearing and vision trouble. The battery of tests done in 1976 were repeated with an additional Otolaryngological examination. Results indicated multiple neurological abnormalities including cerebellar atrophy, revealed by the CT scan, as well as significant decreases in hearing and vision sensitivity. Audiometric tests showed a bilateral, flat sensorineural hearing loss. Progression of hearing loss continued to near deafness within three years and even after extensive repeat examinations no specific cause for the hearing loss could be determined other than that which the toluene in the glue could cause.

An investigation by Biscaldi et al (2), focused on the vestibular findings of six female workers who were accidentally exposed to toluene vapors. Auditory sensitivity of the females was not discussed but audiogram results were shown. The researchers report two examinations were conducted: one fifteen days after exposure and the other after six months. Three of the six workers showed signs of hearing loss. One was found to have an initial dip at 3k Hz in one ear, but recovered after six months. The second showed no sign of a hearing loss at first, but after six months showed a deficit at 6k Hz in one ear. The third showed effects initially at 6k Hz in one ear, and after six months, hearing sensitivity degraded bilaterally at 6k Hz. Even though the number of subjects limits the possibilities for definite conclusions, results from this study indicates the need for further research regarding effects of human exposure to toluene vapors.

Research conducted by Johnson et al (4,5), regarding combined exposures to noise and toluene, prompted Morata et al (7,8) to study the auditory sensitivity of rotogravure printers and paint factory workers with simultaneous occupational exposure to noise and toluene. The relative

risk for developing a hearing loss was found to be eleven times greater for rotogravure printers, exposed to a combination of noise and toluene, as compared to workers not exposed to noise or toluene (non-exposed). Paint factory workers exposed to a solvent mixture, comprised mostly of toluene, xylene, and methyl ethyl ketone, in the absence of noise were found to be five times more likely to develop a hearing loss than the non-exposed group. Workers exposed to noise levels similar to that of rotogravure printers, but not exposed to toluene, were found to be at four times the risk of developing a hearing loss compared to the non-exposed group. Concern was expressed by the authors as to why hearing conservation programs have not taken chemical exposure into consideration as a cause for hearing loss, perhaps leaving many workers with unmet needs in regards to hearing protection.

A literature review by Morata et al (8) cited a 20-year longitudinal study, conducted by Bergstrom et al, concerning the hearing sensitivity of workers from different sectors of industry. A noticeably large number (23%) of the workers from a chemical manufacturing sector showed a pronounced hearing loss, compared to that of workers from a non-chemical sector (5-8%). This loss of hearing sensitivity in workers from the chemical area was found even though the noise levels were lower than the noise levels in a non-chemical sector. Possible chemical exposure was implicated as a causative factor for those hearing losses.

Toluene is used today in both military and civilian applications despite knowledge of its potential hazards. The negative effects of toluene are just now being identified by researchers. The fact that workers may be unknowingly losing their hearing abilities warrants the need for further research regarding the hazards of working with toluene.

One of the more cost effective approaches to take in designing a study on toluene would be to first conduct a retrospective epidemiological study looking at records of exposures in workers from the past five years. This would determine whether or not any prospective research is necessary. If significant changes in hearing sensitivities are found, then a longitudinal study could indicate the health and safety risks of those working with toluene and more specifically those working with a combination of noise and toluene.

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AN ANALYSIS OF OIL/GREASE IN WATER AND SOIL

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AN ANALYSIS OF OIL/GREASE IN WATER AND SOIL

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Abstract

An analysis of oil and grease in water and soil samples was conducted. Water samples were measured in 500 ml flask containers with an addition of freon and Sulfuric Acid. The samples were agitated by hand and by machine for 3 minutes. After this process, the samples were extracted into 10 ml cylinders. Soil samples were weighed out and freon was added. These were stirred for 2 minutes and extracted into cylinders.

Soil and water samples were investigated for pollutants. An analysis of oil and grease was conducted. Water samples wee measured in 500 ml flask containers with freon and Sulfuric Acid added. These samples were agitated by hand and by machine for 3 minutes. After this process, the samples were extracted into 10 ml cylinders. Soil samples were weighed out and freon was added. These samples were stirred for 2 minutes and extracted into cylinders.

AN ANALYSIS OF OIL/GREASE IN WATER AND SOIL

Adriana Y. Lopez

Introduction

The analysis of oil and grease in water and soil is important to any community. If water or soil contains an abnormally high content of oil and grease, it could affect an entire population with deadly results. Farmers and ranchers could suffer if their crops or cattle are subjected to these contaminants. Wildlife could be eradicated because of this environmental threat. Analysis are conducted to make certain that no water or soil supply has been tainted with pollutants. These resources could be polluted by airplane and train accidents involving hazardous materials, industrial pollution, and human carelessness.

Methodology

Water

The analysis of this resource was conducted by using freon and Sulfuric Acid. 500 ml of the sample were poured into a flask. To this, 20 ml of freon and 5 ml of Sulfuric Acid were added. This as shaken by hand to remove excess air from the sample. The flask was placed in a mixing machine for 3 minutes for additional agitation. The container was removed from the machine and placed on a rack. The water, along with the freon and the acid, was suspended as the oil and grease were filtered into a 10 ml cylinder. The sample was run through an IR machine t detect traces of any oil and grease that remained. The observations were recorded.

Soil

Freon was used in this investigation. 50 grams of soil were weighed, and 50 ml of freon were added to each sample. This was hand stirred for 2 minutes to extract the oil and grease from the soil. The sample was filtered into a 25 ml cylinder and run through an IR machine to detect any traces of contaminants in the soil. The findings wee recorded.

A STUDY ON PRODUCTION CONTROL METHODS AND EVALUATION

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A STUDY OF PRODUCTION CONTROL METHODS AND EVALUATION

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Abstract

Methods of production control were studied and utilized. The primary example of this study was the Operations Support Section (FIVCB-Wright Laboratory Research Facility) at the 9700 Area of Tyndall Air Force Base. Various production tracking methods were used to monitor both output and efficiency. Methods of reducing material waste on large contracts were studied and employed. Preexisting methods of work efficiency tracking were improved upon and expanded.

A STUDY OF PRODUCTION CONTROL METHODS AND EVALUATION

Steven James Mattingley
Mosley High School

Introduction

This study deals with the techniques employed in attempting to improve and effectively monitor production at the Operations Support Section. Operations Support is broken down into several shops. The metal shop, electric shop, carpentry shop, and equipment operators were the focus of this study (Vehicle Maintenance was excluded from this study because its day to day operations are radically different from the other four categories). The metal shop is responsible for welding, sheet metal work, and general metal work. Carpentry works on all of the projects involving wood. The electric shop wires all of the buildings and installs electrical devices. The equipment operators run all of the heavy equipment, from bull dozers to tractor trailers. The following section will discuss the methods used to monitor and improve production.

Body

Operations Support operates under a work order system. Work orders are filled out by the requesting person or organization and they contain all of the information necessary to do the job, plus necessary information about the requester or requesting organization. Work orders are processed and given to the individual worker or workers who will be doing the job. To improve the existing system for tracking work, the work orders dated within the last year were placed in a relational database on the computer. A brief description of database components follows: the two major parts of any database are records and fields. The database's manual describes a record as, "One set of related information in a database. For example, in an invoice database each invoice is a record." A field is defined in the database manual as, "A category of information in a database. For example, in an invoice database the fields might be for invoice number, date, name, and amount due." With the data in the database, it became a very important tool for organizing the work orders in ways that revealed exactly how much work everybody was doing and requesting. The database was set up with production control in mind. Each

individual work order had its own record on the computer. The records were divided into various fields. The data may be sorted or filtered by any of the fields which were: Work Order Number, Date, Description, Requester, Workshop, Estimated Completion Date. Request Section. Job Status, Completion Date, and Man Hours. The ability to instantly have a list of all the jobs that aren't complete or a list of all the jobs that a certain section has requested in the past month was tremendously useful. The database also featured man hour totals for each page and a grand total of man hours for the selected work orders. With the self totaling man hour counters in place along with easy find and sort features, it became simple to figure out how many man hours the electrical shop put in the past month or how many man hours of support FIVCO required in the past week.

With the pre-mentioned data organization capabilities in place, extensive labor tracking became rather easy. The data was used to provide "hard" proof of support provided, the needed adjustment for manpower, etc. Having the data in the computer also provided another layer of data protection in case of loss or damage to physical records. The data was even more useful when displayed in a graphical, format. The actual database files were imported into a graphing and charting program that displayed them in an easy to understand format. On page 23-07, an example graph is shown. It shows how many direct man-hours of support the other sections required for a ten month period in bar graph and pie chart forms. Being able to quickly graph and display the organized data proved extremely useful throughout the course of the study.

With the data organized, it was time to do a basic analysis of it (an extensive analysis would have exceeded the cope of this study). A great deal was learned by simply reviewing the database in its raw form. Comparing Estimated Completion Dates with Actual Completion Dates and the man hours spent on a job, yielded a fairly accurate view of efficiency. Although, extraneous factors had to be taken in to account, such as the number of "rush" jobs that came in over the time period, or whether or not the shop was at full manpower. The data helped one see the scope of jobs as well as the shear number.

Another method that the Operations Section used to track production is their Weekly Activity Reports (WAR). A typical WAR contains short bullets describing everything the individual shops did over the week. The WARs are typed into a condensed, easy to read format that shows exactly what was accomplished over the week. An example WAR is shown on page 23-09. It describes exactly what everyone did from July 17 to July 21 (broken

down by shop). The WARs were useful for the purposes of this study because they show indirect labor as well as the direct labor of the work orders.

Another area of "production control" is value engineering. Value engineering, also known as value analysis, is a method used to figure the total value of a part of a project. Value engineering is all about getting the same or better performance at reduced cost. First one looks for redundant or nonessential aspects of a design. The essential portions are also reviewed for ways to eliminate waste. A cost / worth ratio is usually figured for all items so that individual plans can be compared and items that are too costly can be dropped. (Building Estimator's Reference Book 15)

The "real world" example of value engineering for this study was a blue print layout for cutting 1/2 inch plywood sheets. The provided layouts were grossly inefficient for the scope of the project. So new layouts were designed that would maximize wood usage while minimizing the time required to cut the sheet. An example layout is shown on page 23-08; It shows the cuts required to make four of the necessary pieces for the MAAS trailer project. Completing the job with the old layouts would have required 160 sheets of plywood. With the redesigned layouts, only 135 sheets are necessary. Not only will money be saved on materials, but the new layouts feature simple square cuts that can easily be mass produced. So man hours will be saved along with money from the reduced materials cost.

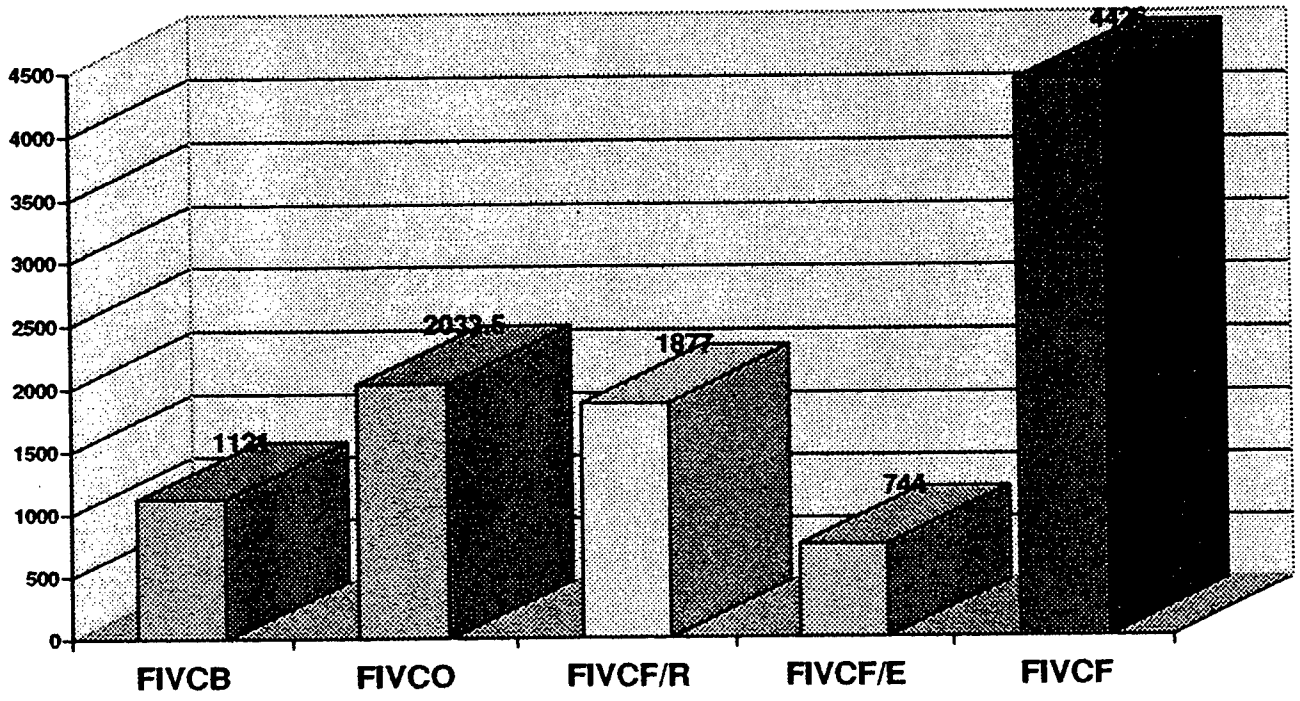
A cost breakdown was undertaken on the MAAS trailer project. On page 23-10, there is the cost breakdown of the project. It shows cost of materials as well as cost of overtime labor. The computerized form of the document automatically adds the columns of numbers generating subtotals. It then adds the subtotals and subtracts that sum from the total budget for the contract. Having an automated document was extremely helpful. The cost breakdown of the MAAS trailer contract ($35,000) showed how efficiently the Operations Support Section was operating.

Conclusion

This study proved to be a success. The Operations Section now knows quite a bit more about how much work it does. The computerized database provided an incredibly flexible tool that helps one organize data. The

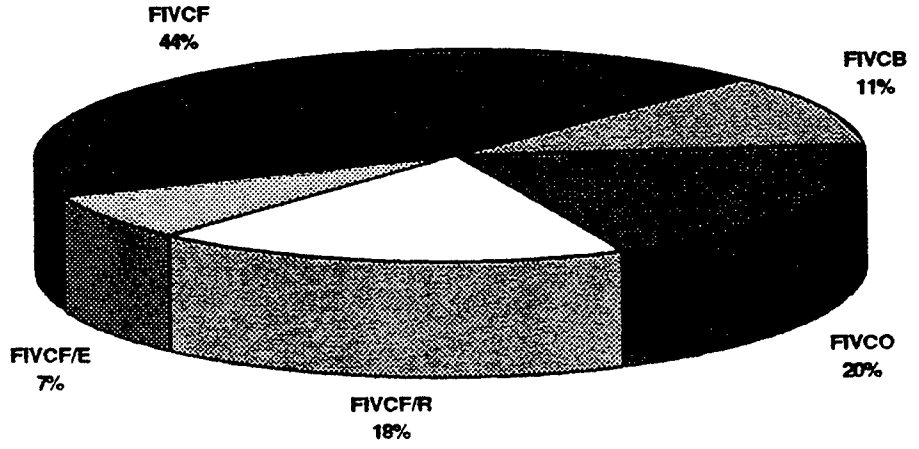
Operations Section can now give quarterly or yearly breakdowns on direct labor with relative ease. Another advantage of having the data on computer is that hard copies can be printed of work orders that have been sorted or filtered in any imaginable way. It is quite easy to give each shop a printing of all of "their" work orders for a given length of time, sorted by completion status. The work order data combined with the WAR data provided an accurate summary of exactly how much work the Operations Section was doing. The information showed exactly what was expected; All of the shops were operating efficiently, but several were operating at reduced man power which lead directly their reduced production. Knowing exactly how much a shop is doing allows on to gauge improvement much more effectively. The knowledge gained from this study shows how, in this age where everyone wants more for their money, production control and evaluation has become a necessary part of doing business.

DIRECT LABOR SUPPORTED BY FIVCB FOR THE PERIOD OF 08AUG 94 - 23JUN 95

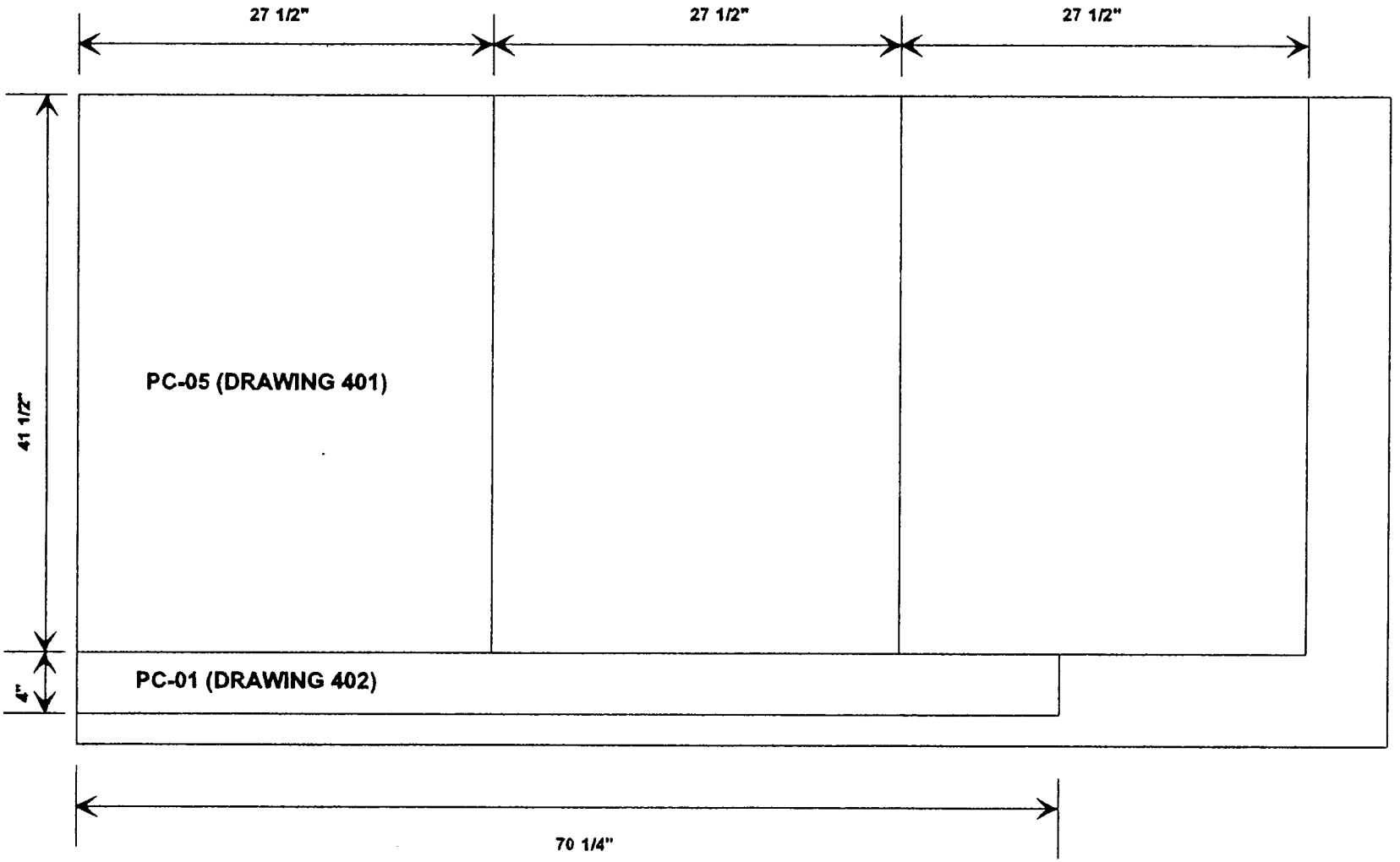


10,152 TOTAL REPORTED MAN HOURS

14,080 TOTAL POSSIBLE MANHOURS FOR EIGHT PEOPLE, 10 MONTHS



MAAS WOOD PROJECT
27 SHEETS 1/2" AC PLYWOOD



FIVCB WAR FOR THE PERIOD OF 17--21 JULY

CARPENTER SHOP
Made repairs to the main water supply system and installed an additional 2.5" piping system at Sky-X. Performed landscaping duties and cut grass in the 9700 area.
(E. DUNCAN/FIVCB/32915)

EQUIPMENT OPERATORS
Assisted metal shop with plane mockup at the fire pit. Loaded and transported APC at Det 1 to 9700 area. Transported contaminated fuel from Sky-X to fire pit. Transported furniture from base supply to 9700 area. Transported guard frame from metal shop to energy lab. Covered trench and graded surrounding area at Sky-X. Transported fire pans for fire. Transported contaminated fuel tank from Sky-X to fire pit and back. Unloaded and set Wanker engine for energy lab. Transported trailer to base for environmental. Hauled scrap metal to salvage yard. Unloaded MAAS trailer containers for BDM at BLDG 9731. Moved lumber and rebar at Sky-X. Hauled load from energy BLDG to storage. Removed water purification apparatus from trailer to storage at BLDG 9731. Hauled waste from Sky-X to 9700 area dumpster. Transported air compressor to Sky-X. (E. DUNCAN/FIVCB/32915)

ELECTRIC SHOP
Repaired conduit for instrumentation at Sky X. Installed water pipe in trench. Assisted Metal shop in building scatter shield for Wanker Engine. Assisted Metal shop in cutting and fitting on plane mock up. Installed 480 Volt outside panel on fire flood BLDG. Picked up parts and tools at main base. Replaced fuses and troubleshot air compressor at the motor pool. Replaced starter heater and disconnect for pump at the fire pit. Disconnected wire at Robotics breakroom. Installed breaker on heater. Installed fuses at the paint shop. Moved materials from 9719 BLDG to fire flood BLDG and laid out holes for conduit. Cut unistrut for conduit at fire flood BLDG. Laid out core chill locations. Began work on light fixtures in bomb BLDG at Sky-X.
(E. DUNCAN/FIVCB/32915)

METAL SHOP
Fabricated scatter shield for Wanker Engine. Serviced air compressor for Vehicle Maintenance. Unloaded steel for Metal shop. Manufactured 2 stainless steel pins with cotter pin holes. Fabricated door for aircraft mockup at the fire pit. Fabricated jigs for BDM MAAS trailer project. Rebuilt smoke grenade for Fire. (E. DUNCAN/FIVCB/32915)

VEHICLE MAINTENANCE
During this reporting period vehicle maintenance has completed work on 23 vehicles (10 scheduled and 13 unscheduled). Twelve vehicles are in maintenance (7 in shop and 5 VDP). We have prepared two vehicles for painting. We have turned in scrap metal / hazardous waste and transported it to main base. Off loaded P-19 fire truck from Nellis, AFB. Our vehicle out of commission rate is 8.5% with 5.2% down for maintenance and 3.3% down for parts.
(E. DUNCAN/FIVCB/32915)

NAME	DATE	HOURS	PAYRATE	MATERIALS	MATERIALS COST	COST
Duncan	19-31 Jul,	24	27.96	Argon gas	1200	671.04
Blackman	19-31 Jul,	20	51	welding wire	300	1020
Himmerich	20 25,31	8	51	elec mtr saw	157	408
Burdett	19-31 Jul,1	24	23.24	weld tools	200	557.76
LA Luzerne	24-28,31	20	22.35	saw blade	100	447
Piper David	26-27,31	14	20.98	Plywood	10300	293.72
Smith	31,jul,1-2	10	22.89	2X4's	752	228.9
				Wood tools	970	0
						0

8/2/95 PAGE 1 MAAS METAL PROJECT FIVCB 13979 3626.42

BUDGET: 35000
TOTAL COST: 17605.42

17394.58

23-10

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The Building Estimator's Reference Book 20th Ed. , Frank R. Walker Company.

Cook, Paul J. Estimitating for the General Contractor , Robert Snow Means Company, Inc. Copyright 1982.

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Acknowledgments

This project was accomplished in full association with Wright Laboratory Operations Support Section (WL/FIVCB) and Edwin Duncan (Chief, Operations Support Section)

A Method for Minimization of Pollution from Diesel Powered Generators

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Armstrong Laboratory
Logistics Research Division

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

August 1995

A Method for Minimization of Pollution from Diesel Powered Generators

Elizabeth A. McKinley
Tecumseh High School Graduate

Abstract

The focus of this report is one possible solution to the growing need for nearly pollution free energy production.

The primary reasons this need is growing are public demand and stricter pollution laws. A discussion of pollution issues from the diesel combustion cycle is included to explain the reasoning behind air pollution laws.

One possible solution to this problem is the use of *unmixed combustion* and *fuel cells* to produce electricity. Unmixed combustion is a process that converts diesel fuel into very pure hydrogen gas to power fuel cells, which create electricity (Lyons). The whole system has the ability to be very clean, but would likely require a lot of equipment, space, and money. However, this proposed system is only at the proof of concept stage and developmental progress may overcome those obstacles.

A Method for Minimization of Pollution from Diesel Powered Generators

Elizabeth A. McKinley

Introduction

As the new millennium approaches, the public is becoming increasingly aware that the future is now. The city and state legislatures, as well as the US Congress have begun to make stricter laws in response to the pubic cry to keep this world livable for the children. Major sources of pollution have been required to follow tighter laws every few years. To avoid being forced to change or modify equipment to comply with new laws, both the public and the commercial operators have begun to strive for pollution free energy.

One technological solution, unmixed combustion, has the potential to allow energy production from diesel fuel to become virtually pollution free. Unmixed combustion produces the 90+% pure hydrogen needed to power fuel cells that produce electricity (Lyons 7). This is accomplished by a catalyst reaction with diesel fuel and water at high temperature and pressure (Lyons 7). The only exhaust from the creation of the hydrogen is SO_2, an easily controlled pollutant gas (Masters 350). Fuel cells have the ability to create electricity from the hydrogen virtually pollution free. Some major complications exist in this process, but it is a step in the right direction.

The Armstrong Laboratory, Logistics Research Division became aware of this approach to emissions reduction as the result of a Small Business Innovative Research (SBIR) proof of concept proposal submitted by the Energy and Environmental Research Corporation of Whitehouse, New Jersey.

Discussion of Problem

The crackdown on air pollution has begun. In the state of California the emission control standards are especially high. March Air Force Base has a limit, as mandated by the law RECLAIM, on the amount of all nitrogen oxides (NO_x, NO_2, NO_3, etc.) that can be emitted from the entire base, which is: 55-ton for 1995, 13-ton for 2000, and 9.5-ton for 2003-2010 (Spurlin 23). March AFB has had difficulty complying with these new airborne emissions regulations. The most important reasons for difficulty with compliance are: the high temperatures and compression ratios needed for diesel operation create nitrogen oxides (mainly NO_x that becomes NO_2, NO_3, etc. in the atmosphere), the existence of regulations for emissions of other criteria pollutants, no good method for diesel emission reduction exists at this time, and the magnitude of the reduction required (Masters 365).

There are, however, several reasons that justify extensive NO_x control. NO_x from combustion can oxidize to NO_2 which forms photochemical smog, acid rain, and destroys stratospheric ozone (Masters 283-291). When NO_2 is at higher than normal concentrations it causes acute irritation of the mucus membranes (Masters 284). Prolonged exposure to relatively low concentrations is linked to increased bronchitis in children and damage to plants (Masters 284). In the form of acid rain, it lowers the pH of water which can cause lakes, ponds, and streams to become unviable for fish and other life, cause crop damage, can corrode metal surfaces, and degrade many building materials (Masters 284). NO_2 apparently does not degrade in the troposphere, but only the stratosphere where it is slowly removed by a reaction with ozone which in turn depletes ozone levels (Masters 431). Stratospheric ozone protects life on earth from damaging and potentially deadly ultraviolet radiation (UV). Increasing the intensity of UV radiation could result in an increase in the frequency of cancers, suppression of immune system response, increase of urban air pollution, animal and plant biological damage and/or death (Masters 431-438). Even a small reduction in stratospheric ozone could have severe negative implications for life on earth.

The burning of diesel fuel produces other harmful pollution besides NO_x. Many particulates smaller than 10μm and can settle into the lung and eventually cause disease (Masters 292). These particulates also decrease visibility by causing haziness, and larger particulates, commonly called soot, settle on buildings and plants causing much of

the dirty look in a city (Masters 292). Carbon monoxide (CO) can have a detrimental impact on human health. Carbon monoxide impairs the blood's ability to carry oxygen to cells in the body. If enough CO is inhaled it can cause death. At lower levels, it can impair the brain's ability to think and react (Masters 282). Carbon dioxide (CO_2) is not usually considered a pollutant, however, in recent years it has been discovered that much of this gas is not being converted back to oxygen because of increased emissions and the reduced quantity of plant life on earth (Masters 391). CO_2 is also closely linked to the greenhouse effect. In fact CO_2 is the sole cause of fifty-seven percent of total global warming (Masters 389). If CO_2 levels get out of hand it could cause the earth to become considerably warmer, which could have many adverse effects to life (Masters 391-412). Reactive organic gases (ROGs) are controlled to help prevent the formation of ozone (O_3) in the troposphere and photochemical smog (Masters 290-291). O_3 causes tree damage, reduces yields of many crops, and is believed to be responsible for ninety percent of all air pollutant damage to agriculture (Masters 291). Photochemical smog causes coughing, shortness of breath, airway constriction, chest tightness, and eye, nose, and throat irritation (Masters 291). Most sulfur contained in the fuel becomes sulfur dioxide (SO_2) during combustion. Once released into the atmosphere SO_2 can become sulfuric acid, which is the principal cause of acid rain (Masters 296). SO_2, can also become sulfate particles. These particles are of the size that they can settle deep inside the lungs and/or impair outdoor visibility (Masters 296). SO_2 can also cause damage to vegetation, paint discoloration, metal corrosion, corrosion of other building materials (marble, limestone, and mortar), and weakening of organic fibers (Masters 296-298) . All of the above pollutant gases, as well as others not mentioned, are formed as a result of untreated diesel combustion. The possibility for further mandated reductions in NO_x and/or other pollutants and the degree of environmental damage caused by these pollutants need to be taken into consideration when considering possible solutions for improved air quality at March AFB to comply with RECLAIM as well as general improvement of diesel operating procedures to decrease all pollution these engines create.

Methodology

In order to better understand the need for a virtual pollution eliminating device, both past environmental laws and potential future laws were evaluated in an attempt to fully understand what emissions the lawmakers were regulating and at what levels. Not only were laws reviewed, but the findings of environmental scientists were examined as well to help predict future legislation. The following paragraphs describe sources of information.

Past and current federal laws were taken from the text *Introduction to Environmental Engineering and Science*. Current South Coast Air Quality Management District (SCAQMD) laws were examined from summaries and explanations of several of the new laws by Major Spurlin (JACE-SCAQ). Environmental research findings and inventions were researched in the *World Wide Web, Introduction to Environmental Engineering and Science*, and various magazine articles. Discussion of environmental topics with both my mentor and her colleague was a valuable resource for reference information and for alternative views on pollution control and unmixed combustion.

Results

Air pollution was first addressed by the federal government in the Air Pollution Control Act of 1955 (Masters 271). Since then the US Congress has passed many laws regarding air pollution. Some of these laws are the Clean Air Act of 1963, the Motor Vehicle Air Pollution Control Act of 1965, the Air Quality Act of 1967, the Clean Air Act Amendments of 1970, the Energy Supply and Environmental Coordination Act of 1974, and the Clean Air Act Amendments of 1977 (Masters 271). Each federal act decreased the allowable level of air pollutants and also added others to the list (Masters 271). Federal law also allows individual states and areas to increase the amount of control and lower the acceptable level of air pollutants (Masters 272). California, in particular the South Coast Air Quality Management District (SCAQMD), has been the place with the most stringent acceptable pollutant levels (Masters 272). However, several different laws have recently been adopted by the SCAQMD with conflicting levels of allowable pollution, particularly NO_x levels (Spurlin 3). Although there exists conflicting guidance, the standards set by these laws are higher than the standards set by previous laws (Page 26). The trend

produced by the SCAQMD seems to indicate that they may adopt a virtually zero pollution law some time in the not to distant future. Other areas and states are expected to follow California's lead in these significant reductions.

In response to these new laws many businesses as well as the government itself has been trying to develop and acquire new pollution controls and/or implement pollution reduction equipment. The concept of unmixed combustion to create hydrogen for fuel cell use was investigated to determine the effectiveness of the conversion from diesel to hydrogen, its pollution reduction capabilities, and how easily it could be implemented.

The basic concept of unmixed combustion is that fuel and air are never mixed, yet it creates the same amount of heat as conventional combustion (Lyons 7). This method of using diesel as a fuel is much cleaner and also more efficient than conventional methods (Lyons). The fuel cells themselves are also energy efficient and virtually pollution free.

The process of unmixed combustion begins when steam and diesel fuel react with each other with exposure to a nickel catalyst (NiO) and calcimined limestone (CaO) under great heat and pressure (700 °C and 8atm) (Lyons 7). These reactions create some water, and several different solids and gases (Lyons 7). The objective is to end up with pure H_2 for use in fuel cells (Lyons 6). The solids and water do not contaminate the H_2. The water can be reused in the generator along with the diesel (which amounts to a 20% savings in water consumption) (Lyons 33). However, these solids would contaminate the NiO and CaO, but when air runs through the system the solids break down and the catalysts are regenerated (Lyons 7). SO_2 (a by product of the H_2S conversion) is also formed, but it is swept out with the air (Lyons 9). The gases CO, CO_2, and H_2S do contaminate the H_2 therefore there is a need for further purification (Lyons 7). The worst pollutant is the H_2S because it is an airborne criteria pollutant and a poison to fuel cells (Masters 295; Lyons 9). Most of it can be removed in the first part of the process, but in the second part it becomes SO_2 (the only exhaust) because it is exposed to air (Lyons 9). SO_2 is also a pollutant, but is easily controlled by injecting a mixture of limestone and water into the SO_2 which can remove 90% of the gas causing a sludge of calcium sulfite or a calcium sulfate precipitate (gypsum) to form (Masters 350). The calcium sulfite can be oxidized to form gypsum which can be used in the construction industry (Masters 350). In fuels that have a high S content (2000ppm by weight) even further purification is necessary to reduce the H_2S to less than

1ppm (Lyons 34). CO and CO_2 also need to be in very small amounts to allow use in fuel cells, so these gas levels also need to be reduced (Lyons 34). (The experiments indicated that all gasses requiring further reduction can be reduced to acceptable levels by using a second reactor at a lower temperature, 510°C (Lyons 33-34).) Any hydrocarbons formed can be sent back to the reactor to generate H_2 (these have been determined to be present, but the amount is unknown) (Lyons 33).

Once the reactions begin, no further heating is needed because the reactions are all slightly exothermic, and more than enough heat is produced to supply all heat losses due to steam production and heat exchanger inefficiency (Lyons 24). There is no possibility for a temperature runaway because of the way that the heat is produced (the final stable temperature is 848°C) (Lyons 12). The calculated efficiency for converting fuel to hydrogen is 86.8% (Lyons 24). The 10kw fuel cells need two reactors that are each .703 ft^3 and weigh 23 lbs and two reactors that purify the hydrogen gas (purification reactors) that are each .21 ft^3 (Lyons 34). This information is based on the following assumptions: the fuel to H_2 reaction is 80% efficient, the fuel cell system is 55% efficient, and the reactors are used with 10 min. fuel/10 min. air cycle (Lyons 34). Also, the purification reactor was an initial experiment with no effort to optimize the results (Lyons 34). It is possible that better results could be achieved without using the purification reactor therefore reducing the amount of equipment needed (Lyons 34).

Loss of the catalytic activity did not appear to be a problem during a 96 hour run (Lyons 35). An experiment also showed that as long as any CaO remains (5.5%) that the H_2 purity does not fall below 87.4% (Lyons 28). Once the CaO is exhausted H_2 purity falls to 60+% (Lyons 28). Fuel cells will not function if the fuel (hydrogen gas) is contaminated (Lyons 6). For optimal fuel cell performance the purity of the H_2 would be 100%.

Energy and Environmental Research Corporation believes that its new technology is potentially capable of meeting the following requirements based on this Phase I research: have weight and volume requirements not greater than the fuel cells, convert a large fraction of the chemical energy of the logistics fuel into hydrogen chemical energy, have minimal water consumption, provide hydrogen of high purity with respect to CO and H_2S without allowing sulfur to accumulate, be simple enough that it can run with minimal operator attention (Lyons 35).

Conclusion

The focus of this work was to assess the need for pollution free energy, and the probability of unmixed combustion and fuel cells fulfilling that need. Research on past pollution legislation was done to determine the possible scope and impact of future laws. The concept of using unmixed combustion to power fuel cells was also investigated to determine how effective its pollution reduction and/or elimination capabilities were and how readily it could be implemented.

Although unmixed combustion is almost pollution free, its downfalls lay in size and expense. An enormous reactor with huge hydrogen storage tanks and fields of fuel cells would be needed to power even a small city. This concept is a simple modification to existing technology, but requires the use of all new equipment. The use of unmixed combustion with fuel cells to create electricity with existing technology would expend a lot of space and a lot of expensive equipment to create small amounts of electricity. Unmixed combustion can efficiently (approximately eighty percent efficient) produce very pure hydrogen for use in fuel cells. Fuel cells are virtually pollution free. The efficiency of fuel cells increases with improved technology almost daily. Unmixed combustion produces only one pollutant, which is easily controlled. The use of diesel fuel to create hydrogen allows fuel cells to operate in any weather. Even though this process has many excellent capabilities, many aspects (size, cost) cause it to be undesirable as a major source of electric power. Unmixed combustion could provide back up power for solar cells, but it still probably would not be very practical until fuel cell technology improves.

The need for nearly pollution free energy is real. The past trends in environmental lawmaking have been to raise environmental standards at the expense of taxpayers and industry. There is no indication that these standards will decrease, in fact the opposite is anticipated. Federal and state laws attempt to keep the environment from getting any worse in hope that it's not too late. Although the concept addressed in this report is probably not the optimal solution, it is still a step in the right direction and warrants further development.

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Associate did not participate in program.

VERTICAL EYE MOVEMENTS INDICATE USE OF TEMPORAL LOBES

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Final Report for:
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Armstrong Laboratory

Sponsored by:
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Bolling Air Force Base, DC

and

Armstrong Laboratory

August 1995

VERTICAL EYE MOVEMENTS INDICATE USE OF TEMPORAL LOBES

Shannon J. Murphy
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Abstract

A study of vertical eye movement in relationship to use of memory was made. The eye movements of 24 subjects were recorded while being asked 24 questions requiring use of the temporal lobes of the brain. The analysis revealed that the majority of vertical eye movements made after any question were in an upward movement. For two out of three types of questions, the bias of the eyes in an upward movement was significant. Horizontal eye movements were also scored, but no significant bias was found for left vs. right eye movement. These data suggest that the human eyes are biased in an upward movement when using the temporal lobes.

VERTICAL EYE MOVEMENTS INDICATE USE OF TEMPORAL LOBES

Shannon J. Murphy
Keystone School

Introduction

According to a preceding study[2], eye movements can be used to indicate brain lateralization. Eyes tend to role to the left when using the right brain and to the right when using the left brain[2]. Yet, no study has heretofore been made about eye movements as an indicator of whether the upper or lower brain is used. This experiment is based on Previc's[3] hypothesis that when the brain's temporal lobes are in use, eye movements are biased to the upper visual field. In a recent study, Previc[4] showed that vertical eye movements are biased upwards during visual search that requires the use of the temporal lobes (located in the lower brain). Visual memory and analytical thinking also require use of the temporal lobes, therefore suggesting that when thinking or using memory eyes may be biased toward the upper visual field, just as they are during visual search.

Method

Subjects. The subjects who participated in this experiment were visitors or employees of Brooks Air Force Base. There were 14 males and 10 females who ranged in age from 17 to 54 years (mean age=30.9 years). All subjects were right-handed, right-footed, and right-eyed. The subjects were naive to the purpose of the experiment and signed a consent form before they were tested.

Apparatus. The apparatus consisted of a half cylinder (44 inches in diameter and 36 inches high) made of low reflective, flat, black aluminum and a black wood base. 25 1 cm diameter holes were cut in the half cylinder within a radius of 10 inches from the center of the half cylinder at eye level. A Zenith VM 6000 movie camera was placed behind the hole in the center making the camera 31 inches away from a subject. Reflective, black plastic was taped behind the other 24 holes over washers disguising the fact that a camera was behind the center hole and creating the illusion that all of the holes were the same. A TV and VCR were set up to the side of the half cylinder and connected to the camera. Three lights were fixed over the half cylinder with an illuminance of 115 FC to allow enough light to reflect off the subject's face and pass through the hole to the camera.

Questions. The 24 questions asked of each subject consisted of 8 proverbs questions (see Fig. 1), 8 arithmetic questions (see Fig. 2), and 8 visual orientation questions (see Fig. 3). Kinsbourne used proverbs, arithmetic, and visual orientation questions in his study[2]. The 8 proverbs questions were taken from Gorham's proverbs test[1]. The 8 arithmetic questions were based on 8 arithmetic problems in Wechsler's WAIS-R manual[6]. The 8 visual orientation questions were based on a display of 9 figures of various shapes and colors that the subject was required to try to memorize given 30 seconds (see Fig. 4).

Proverbs Questions

Subjects were asked to describe the deeper meaning of the following proverbs.

1. Don't judge a book by its cover.
2. Rome was not built in a day.
3. When the cat's away the mice will play.
4. Barking dogs seldom bite.
5. Don't cry over spilled milk.
6. Strike while the iron is hot.
7. A stream can not rise higher than its source.
8. Let sleeping dogs lie.

Fig. 1. Proverbs questions.

Arithmetic Questions

Subjects were asked the solve the following arithmetic problems.

1. How many *hours* will it take a person to run *56 miles* at *7 m/p/h*? **8 hours**
2. If you buy *6 30-cent* stamps with *2 dollars*, how much *change* should you get? **20 cents**
3. How many *inches* tall is a *5'4"* person? **64 inches**
4. A family drove *250 miles* in *5 hours*. What was their *average* speed. **50 m/p/h**
5. The price of apples is *3 for 30 cents*. What is the price of *1 dozen* apples? **$1.20**
6. A family bought some furniture for *three-fourths* the cost and paid *270 dollars*. What was the *original cost*? **360 dollars**
7. A coat that is *normally 75 dollars* is reduced by *1/3* during a sale. What is the *sale price*? **50 dollars**
8. If *30 ants* can eat *6 sugar cubes* in a day, how many ants will it take to eat *2 sugar cubes* in a day? **10 ants**

Fig. 2. Arithmetic questions and answers.

Visual Spatial Orientation Questions

1. Is the red circle to the right or left of the blue star? **left**
2. Is the yellow cross above or below the grey rectangle? **below**
3. How many red shapes are there? **2**
4. Is the orange diamond to the right or left of the red arrow? **left**
5. How many triangles are there? **1**
6. Is the grey rectangle above or below the blue hexagon? **above**
7. How many stars are there? **2**
8. Is the green triangle to the right or left of the purple star? **right**

Fig. 3. Spacial orientation questions and answers.

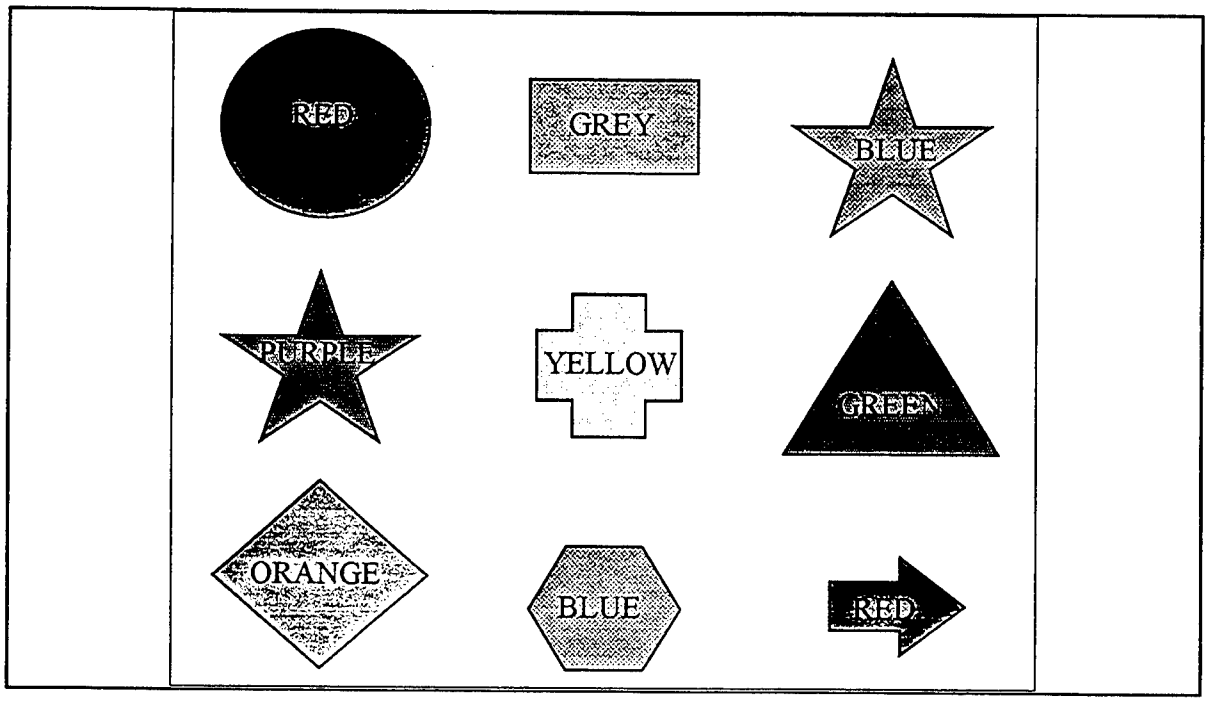

Fig. 4. A black and white version of the display subjects were required to try to memorize before being asked the 8 visual spacial questions. The name of the color did not appear in the colored version.

Procedure. When video camera, TV, VCR, and lights were on, the subject sat down in front of the half cylinder facing the holes. The subject put his/her chin in a chin-rest, which situated the right eye in direct view of the camera. The chin-rest was adjusted to center the right eye on the TV screen and the VCR recorder was started. Instructions were read to the subject explaining that 24 questions would be asked, that each question would be asked only once, and that the subject must keep his/her head in the chin-rest at all times, gaze at the holes while a question was being read, avoid blinking, and come up with answers as quickly as possible. The three sets of 8 questions were read in a random sequence. Subjects were asked to try to memorize the colors shapes and layout of the figures in the display of 9 shapes (see Fig. 4) for 30 seconds before being asked the visual spacial questions. After all 24 subjects were run, the tape was reviewed and the eye movements were recorded on paper. The first eye movement after each question, repeated question, or repeated segment of a question was recorded as up, down, right, left, up and right, up and left, down and right, down and left, no change, or uncertain. An eye movement was considered uncertain if the eyes were closed, if the subject was talking, if the eyes were constantly moving during the question, or if the subject asked a question about the

question that required a yes/no answer as opposed to repeating the question. Two other judges, who were naive to the hypothesized results of the experiment, besides the investigator judged and recorded the eye movements from the video tape. Where the two other judges disagreed in an eye movement, the investigator's recorded data were used. Where the two judges agreed on an eye movement, their recorded data was used. The congruence of the data of the two judges was over 80%.

Results

Up vs. Down Results. Fig. 5 shows the data for up and down eye movements during the arithmetic questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked up more than down during the arithmetic questions is significantly more than the number of subjects who looked down more than up. Therefore it can be concluded that human eyes are biased upwards when using analytical thinking in arithmetic.

Arithmetic Up vs. Down Signs

Subject #	Arithmetic Up	Arithmetic Down	Direction of Difference	Sign
1	1	1	U=D	0
2	2	0	U>D	'+'
3	2	0	U>D	'+'
4	2	0	U>D	'+'
5	3	1	U>D	'+'
6	2	0	U>D	'+'
7	3	0	U>D	'+'
8	4	0	U>D	'+'
9	2	0	U>D	'+'
10	0	2	U<D	'-'
11	1	0	U>D	'+'
12	1	0	U>D	'+'
13	1	0	U>D	'+'
14	1	0	U>D	'+'
15	3	0	U>D	'+'
16	2	2	U=D	0
17	0	3	U<D	'-'
18	2	4	U<D	'-'
19	0	1	U<D	'-'
20	0	0	U=D	0
21	1	0	U>D	'+'
22	1	0	U>D	'+'
23	0	0	U=D	0
24	0	0	U=D	0

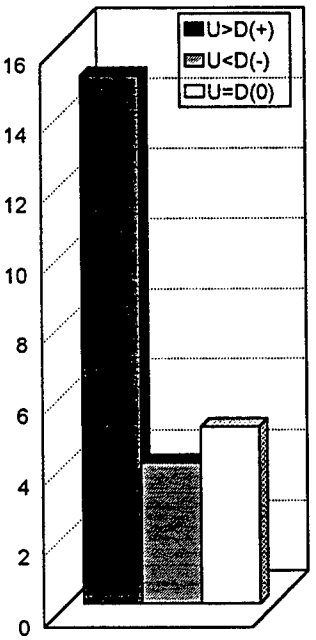

Fig. 5. N = all +s and -s = 19, x = # of smaller sign (-) = 4, α = .050, and 2(P) for *Ho* = .020.

2(P) is less than α, therefore the difference is significant.

Fig. 6 shows the data for up and down eye movements during the proverbs questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked up more than down during the proverbs questions is insignificantly more than the number of subjects who looked down more than up. Therefore the results for eye movements during the proverbs questions are inconclusive.

Proverbs Up vs. Down Signs

Subject #	Proverbs Up	Proverbs Down	Direction of Difference	Sign
1	2	0	U>D	'+'
2	1	0	U>D	'+'
3	0	1	U<D	'-'
4	4	0	U>D	'+'
5	1	1	U=D	0
6	0	1	U<D	'-'
7	1	0	U>D	'+'
8	2	0	U>D	'+'
9	2	0	U>D	'+'
10	1	3	U<D	'-'
11	0	0	U=D	0
12	1	0	U>D	'+'
13	0	0	U=D	0
14	0	0	U=D	0
15	2	1	U>D	'+'
16	1	3	U<D	'-'
17	0	1	U<D	'-'
18	0	3	U<D	'-'
19	0	1	U<D	'-'
20	0	0	U=D	0
21	0	0	U=D	0
22	0	0	U=D	0
23	1	0	U>D	'+'
24	1	0	U>D	'+'

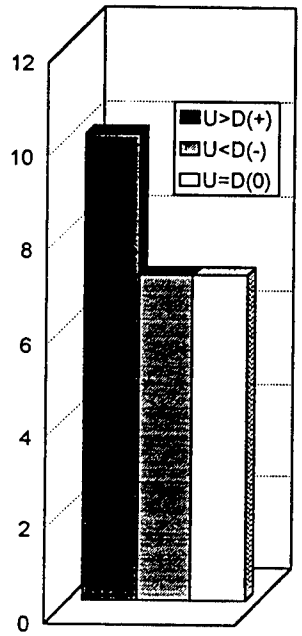

Fig. 6. N = all +s and -s = 17, x = # of smaller sign (-) = 7, α = .050, and 2(P) for *Ho* = .630.

2(P) is not less than α, therefore the difference is insignificant.

Fig. 7 shows the data for up and down eye movements during the visual orientation questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked up more than down during the visual orientation questions is significantly more than the number of subjects who looked down more than up. Therefore it can be concluded that human eyes are biased upwards when using visual memory.

Visual Orientation Up vs. Down Signs

Subject #	Visual Up	Visual Down	Direction of Difference	Sign
1	0	0	U=D	0
2	0	1	U<D	'-'
3	1	0	U>D	'+'
4	3	0	U>D	'+'
5	4	0	U>D	'+'
6	0	0	U=D	0
7	2	0	U>D	'+'
8	2	1	U>D	'+'
9	5	0	U>D	'+'
10	0	0	U=D	0
11	0	0	U=D	0
12	2	0	U>D	'+'
13	0	0	U=D	0
14	0	0	U=D	0
15	1	0	U>D	'+'
16	0	2	U<D	'-'
17	0	0	U=D	0
18	0	0	U=D	0
19	2	1	U>D	'+'
20	0	0	U=D	0
21	0	0	U=D	0
22	0	0	U=D	0
23	1	0	U>D	'+'
24	0	0	U=D	0

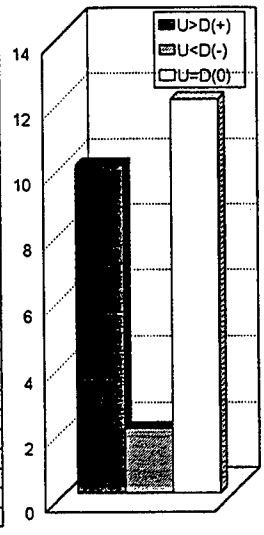

Fig. 7. N = all +s and -s = 12, x = # of smaller sign (-) = 2, α = .050, and 2(P) for *Ho* = .038. 2(P) is less than α, therefore the difference is significant.

Total Up vs. Down Signs

Subject #	Total Up	Total Down	Direction of Difference	Sign
1	3	1	U>D	'+'
2	3	1	U>D	'+'
3	2	1	U>D	'+'
4	9	0	U>D	'+'
5	8	2	U>D	'+'
6	2	1	U>D	'+'
7	6	0	U>D	'+'
8	8	1	U>D	'+'
9	9	0	U>D	'+'
10	1	5	U<D	'-'
11	1	0	U>D	'+'
12	4	0	U>D	'+'
13	1	0	U>D	'+'
14	1	0	U>D	'+'
15	6	1	U>D	'+'
16	3	7	U<D	'-'
17	0	4	U<D	'-'
18	2	7	U<D	'-'
19	2	3	U<D	'-'
20	0	0	U=D	0
21	1	0	U>D	'+'
22	1	0	U>D	'+'
23	2	0	U>D	'+'
24	1	0	U>D	'+'

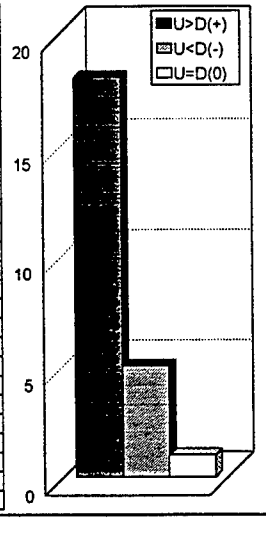

Fig. 8. N = all +s and -s = 23, x = # of smaller sign (-) = 5, α = .050, and 2(P) for *Ho* = .010. 2(P) is less than α, therefore the difference is significant.

Fig. 8 shows the combined data for up and down eye movements during all of the questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked up more than down during all of the questions is significantly more than the number of subjects who looked down more than up. Therefore it can be concluded that human eyes are biased upwards when using visual memory and analytical thought

Left vs. Right Results. Fig. 9 shows the data for left and right eye movements during the arithmetic questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked left more than right during the arithmetic questions is insignificantly more than the number of subjects who looked right more than left. Therefore the results for eye movements during the arithmetic questions are inconclusive.

Arithmetic Left vs. Right Signs

Subject #	Arithmetic Left	Arithmetic Right	Direction of Difference	Sign
1	1	1	L=R	0
2	1	0	L>R	'+'
3	0	1	L<R	'-'
4	1	5	L<R	'-'
5	6	0	L>R	'+'
6	1	2	L<R	'-'
7	1	1	L=R	0
8	3	1	L>R	'+'
9	1	3	L<R	'-'
10	3	1	L>R	'+'
11	2	0	L>R	'+'
12	0	2	L<R	'-'
13	0	1	L<R	'-'
14	2	0	L>R	'+'
15	3	0	L>R	'+'
16	4	0	L>R	'+'
17	2	1	L>R	'+'
18	0	5	L<R	'-'
19	1	0	L>R	'+'
20	0	0	L=R	0
21	2	0	L>R	'+'
22	1	1	L=R	0
23	0	1	L<R	'-'
24	1	0	L>R	'+'

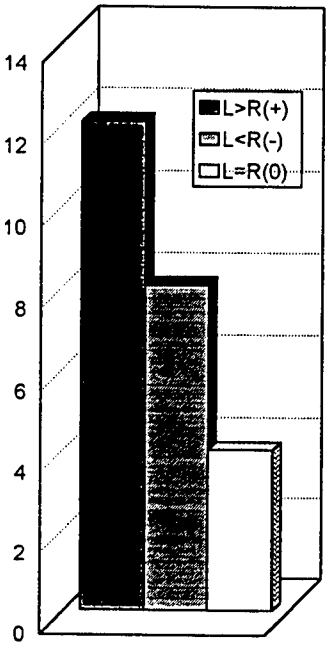

Fig. 9. N = all +s and -s = 20, x = # of smaller sign (-) = 8, α = .050, and 2(P) for *Ho* = .504.

2(P) is not less than α, therefore the difference is insignificant.

Fig. 10 shows the data for left and right eye movements during the proverbs questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked left more than right during the proverbs questions is insignificantly more than the number of subjects who looked right more than left. Therefore the results for eye movements during the proverbs questions are inconclusive.

Proverbs Left vs. Right Signs

Subject #	Proverbs Left	Proverbs Right	Direction of Difference	Sign
1	1	1	L=R	0
2	1	1	L=R	0
3	1	4	L<R	'-'
4	3	3	L=R	0
5	3	1	L>R	'+'
6	2	1	L>R	'+'
7	2	1	L>R	'+'
8	2	0	L>R	'+'
9	5	0	L>R	'+'
10	2	1	L>R	'+'
11	0	0	L=R	0
12	0	2	L<R	'-'
13	1	0	L>R	'+'
14	1	0	L>R	'+'
15	1	6	L<R	'-'
16	0	4	L<R	'-'
17	7	0	L>R	'+'
18	2	2	L=R	0
19	2	0	L>R	'+'
20	0	2	L<R	'-'
21	0	0	L=R	0
22	1	0	L>R	'+'
23	1	4	L<R	'-'
24	0	0	L=R	0

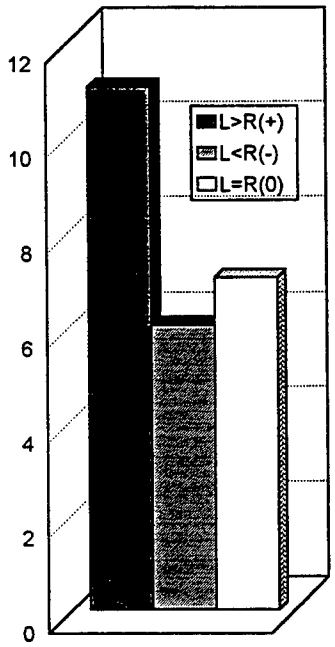

Fig. 10. N = all +s and -s = 17, x = # of smaller sign (-) = 6, α = .050, and 2(P) for *Ho* = .332.

2(P) is not less than α, therefore the difference is insignificant.

Fig. 11 shows the data for left and right eye movements during the visual orientation questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked left more than right during the visual orientation questions is insignificantly less than the number of subjects who looked right more than left. Therefore the results for eye movements during the visual orientation questions are inconclusive.

Visual Orientation Left vs. Right Signs

Subject #	Visual Left	Visual Right	Direction of Difference	Sign
1	0	1	L<R	-
2	0	0	L=R	0
3	0	3	L<R	-
4	0	3	L<R	-
5	0	5	L<R	-
6	1	0	L>R	+
7	3	1	L>R	+
8	1	1	L=R	0
9	5	0	L>R	+
10	1	1	L=R	0
11	0	7	L<R	-
12	2	0	L>R	+
13	0	0	L=R	0
14	2	2	L=R	0
15	0	3	L<R	-
16	0	1	L<R	-
17	3	1	L>R	+
18	0	0	L=R	0
19	2	1	L>R	+
20	0	1	L<R	-
21	0	0	L=R	0
22	0	0	L=R	0
23	0	1	L<R	-
24	0	0	L=R	0

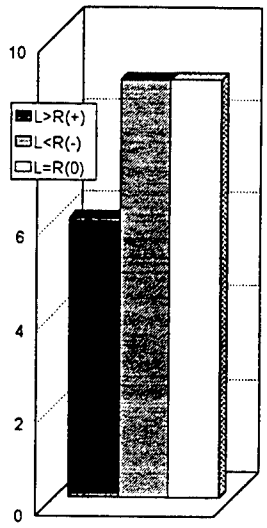

Fig. 11. N = all +s and -s = 15, x = # of smaller sign (+) = 6, α = .050, and 2(P) for *Ho* = .608.

2(P) is not less than α, therefore the difference is insignificant.

Total Left vs. Right Signs

Subject #	Total Left	Total Right	Direction of Difference	Sign
1	2	3	L<R	-
2	1	2	L<R	-
3	2	7	L<R	-
4	8	7	L>R	+
5	3	12	L<R	-
6	5	2	L>R	+
7	6	3	L>R	+
8	4	4	L=R	0
9	13	1	L>R	+
10	4	5	L<R	-
11	0	9	L<R	-
12	4	2	L>R	+
13	2	0	L>R	+
14	3	4	L<R	-
15	1	12	L<R	-
16	0	9	L<R	-
17	11	3	L>R	+
18	7	2	L>R	+
19	4	2	L>R	+
20	0	3	L<R	-
21	0	2	L<R	-
22	2	1	L>R	+
23	2	5	L<R	-
24	0	1	L<R	-

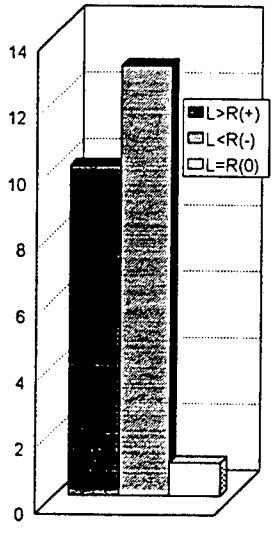

Fig. 11. N = all +s and -s = 23, x = # of smaller sign (+) = 10, α = .050, and 2(P) for *Ho* = .678.

2(P) is not less than α, therefore the difference is insignificant.

Fig. 12 shows the combined data for left and right eye movements during all of the questions and how a sign test was performed[5]. The sign test shows that the number of subjects who looked left more than right during all of the questions is insignificantly less than the number of subjects who looked right more than left. Therefore the results for eye movements during all of the questions are inconclusive.

Conclusion

The only significant results were of the arithmetic, visual orientation, and total up vs. down eye movements. In all cases the results were that the number of subjects who looked up more than down was significantly greater than the number of subjects who looked down more than up. Because all of the questions required use of the temporal lobes of the brain and all questions, except the proverbs questions, showed a significant bias of the eyes to the upper visual field, it can be concluded that a bias of eye movements towards the upper visual field indicates the use of the temporal lobes of the brain.

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ABSTRACT TESTS PREDICTING PERFORMANCE ON REALISTIC TESTS

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Final Report for:
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ABSTRACT TESTS PREDICTING PERFORMANCE ON REALISTIC TESTS

Jennifer Patterson

John Marshall High School

ABSTRACT

This study was conducted to determine if more abstract and less expensive tests can predict the performance on more realistic and more expensive tests. Each subject took a battery of tests which lasted approximately three and a half hours. The battery of tests was composed of two psychomotor skills tests, which test hand/eye and multilimb/eye coordination, and a situation awareness test, and two driving simulators, one administered on a personal computer and the other on a modified arcade game. The results showed some significant correlations between the abstract tests and the two driving simulators. There were also some significant correlations between the abstract tests which required similar skills.

ABSTRACT TESTS PREDICTING PERFORMANCE ON REALISTIC TESTS

Jennifer Patterson

INTRODUCTION and DISCUSSION of PROBLEM

This study was conducted to validate personal-computer-based tests of psychological knowledge. This was done by testing whether abstract PC-based tests can predict performance on a realistic driving simulator. Two types of psychological knowledge were tested in these tests. The first type was situational awareness. This knowledge focuses on the subject's awareness of the objects around him, and how well can he remember where the objects are and what are they doing. This knowledge was tested through the use of a spatial working memory test and a driving simulator given on a personal computer. The purpose of these tests is to determine if the tests can predict the subject's performance on the obstacle course of the ATARI driving simulator.

The other type of psychological knowledge is psychomotor skills. Psychomotor skills refer to a subject's ability to coordinate their limbs, eyes, and mind to complete a task. These skills were tested through the use of two coordination tests. One tested hand/eye coordination through the use of a joystick, and the other tested multilimb coordination with the subject using both a joystick and foot pedals simultaneously. The purpose of these tests is to determine if the tests can predict the subject's performance on the motor course of the ATARI driving simulator. The tests administered on the personal computers are less expensive, and more abstract than the ATARI driving simulator, which is more realistic and more expensive.

METHODOLOGY

SUBJECTS

The 20 subjects were selected randomly from a group of recruits on Lackland Air Force Base. The subjects had valid driver's licenses and ranged in age from 18 to 24.

COGNITIVE ABILITY TESTS

These tests were given on personal computers in the Cognitive Abilities Measurement Lab at Lackland Air Force Base. They had four hours to complete the tests. Each computer was equipped with a color monitor, keyboard, mouse, joystick, foot pedals, and headphones. These accessories were not used with all the tests, but they were all used sometime during the testing session.

CIRCULAR PURSUIT (hand/eye coordination) : A red ball is moving at changing speeds on a circular path. With the joystick, the subject controls the speed of a smaller, yellow ball, which is also moving on the circular path. The subject's task is to keep the yellow ball as close to the red ball as possible, forcing the subjects to react to the red ball's changing speeds.

CENTER THE BALL (multilimb/eye coordination) : There is a target in the middle of the screen. The subject controls a cyan ball with a joystick and foot pedals. The joystick moves the ball up and down, and the foot pedals move the ball left and right. The subject's task is to keep the ball on the target by correcting the always changing movement of the ball.

FIGURE SYNTHESIS X-Y-Z ASSIGNMENT (spatial working memory) : The subject is given an equation like problem whereas instead of numbers, the subject must add or subtract line segments from a figure. After three problems, the subject must remember what each final figure looked like, and in the right order.

DRIVING QUESTIONNAIRE : The subject is asked questions to determine how much driving experience they have, how long they have been driving, and how many accidents they have been in or caused.

RISK QUESTIONNAIRE :

Risky Activity : The subject is given a series of statements that say certain activities are risky. The subject then strongly agrees, somewhat agrees, strongly disagrees, somewhat disagrees, or is neutral on the subject.

Activity Frequency : The subject is given a series of statements, which include the activities in the Risk Activity Questionnaire, and they are to answer with how often they perform these activities, selecting from never, rarely, sometimes, often, or always.

SIMULATORS

PC-BASED DRIVING SIMULATOR : This is a driving simulator that was administered on a personal computer. The instructions are given to the subject through the use of headphones and prerecorded instructions, which explain what they are seeing on the screen. The subject can see the cars in front of him, and he can also see the cars behind and beside him through the use of the rear view mirrors. The car is on "auto pilot." The subject does not need to be concerned with the speed or the steering of their car. This is all controlled by the computer. The subject's car stays in one lane, at one speed through the entire trial, unless the subject makes a reaction to respond to the movement of another car. The trials are 18 to 35 seconds long. The subject responds to a potentially dangerous situation by making a driving response by using the arrow keys. The subject can accelerate slowly, change lanes quickly to the left or right, or brake immediately. The subject must make a driving response in 60% of the trials, and in the remaining 40%, the correct action is to make no response.

ATARI : This Driving Simulator is a arcade game modified to resemble a more realistic driving environment. The subject sits in a seat and faces three monitors, one in the center and one on each side. The simulator is equipped with all the necessary controls of an actual car, which include a steering wheel, brake, accelerator, simulated mirrors and dash panel, and a gear shift, in which the clutch has been disabled because not all drivers are familiar driving a standard.

Practice Course : This practice session is given to familiarize the subject with the controls of the ATARI, especially with the rearview and side mirrors.

Obstacle Course : The subject is presented with thirty-eight situations. Twenty-four require a reaction by the driver to avoid collision and/or failing the trial. Mixed in with these trials are fourteen nonhazardous situations. The nonhazardous situations require no reaction by the driver, but are there merely to make the driving environment more realistic, because not every situation a driver comes to is going to be dangerous and require a reaction.

Motor Course : During this portion of the test, the subject is asked to maintain a speed of 60 miles per hour and to drive in the center of the right lane. In the course there are no obstacles to distract the driver. All the subject must do is concentrate on the car's speed and lane position.

PROCEDURE

On Tuesdays and Wednesdays, Air Force recruits were tested at Lackland Air Force Base. On these days, four recruits were selected randomly from the flights. The only qualifications needed for our testing was a valid driver's license. Twenty recruits were tested on the tests mentioned above. The total testing time was approximately three and a half hours. The tests were given in a random order and the subjects were given periodic breaks.

RESULTS

SCORING

CIRCULAR PURSUIT : The distance between the two balls was sampled 72 times every second. The mean distance was 24.4 degrees and the standard deviation was 9.6 degrees.

CENTER THE BALL : The subject took two testing sessions of this test. Approximately 10,000 times during each testing session, the distance of the ball was sampled and figured in to a total average. For the first session, the average distance from the target was 10.17 cm and the standard deviation was 1.04 cm. For the second session, the average distance was 9.71 cm and the standard deviation was 0.94 cm.

PC-BASED DRIVING SIMULATOR : The percent correct was composed of the number of trials in which the subject avoided a collision. The mean percent correct was 64% and the standard deviation was 11%.

ATARI :

Obstacle Course : Each trial in the course had a certain criterion which was used to determine whether the subject passed or failed the trial. The percent correct was the number of trials the subject passed, out of the total number of trials that required an action from the driver. The mean percent correct was 70% and the standard deviation was 7%. The number of collisions was counted for each subject. The mean number of collisions was about 6 and the standard deviation was 1.35.

Motor Course : The subject's speed and lane position was sampled 16 times a second. The mean speed of all the drivers was 61.89 mph and the standard deviation was 2.02 mph. The mean distance from the center of the lane was 2.56 feet to the right of the center, and the standard deviation was 1.85 feet.

CORRELATIONS

PC-BASED DRIVING SIMULATOR -- ATARI OBSTACLE COURSE: There was not a significant correlation between the percentage of hazards avoided in the PC-based driving simulator and the ATARI obstacle course (Pearson's r of -0.22, $p = 0.334$). In fact, performance on the ATARI obstacle course did not significantly correlate with any of the other tests.

PSYCHOMOTOR TESTS -- ATARI MOTOR COURSE : There was a significant correlation (Pearson's r) of 0.58 between the subjects' average distances on the Circular Pursuit test and the subjects' standard deviations of speed on the ATARI motor course ($p = 0.008$). The subjects with a lower mean distance on Circular Pursuit were more consistent in maintaining their speed on the ATARI motor course.

COORDINATION TESTS : There was a significant correlation (Pearson's r) of 0.47 between the mean distance on the first session of Center the Ball and the mean distance on Circular Pursuit ($p = 0.035$). There was also a significant correlation (Pearson's r) of 0.52 between the mean distance on the second session of Center the Ball and the mean distance on the Circular Pursuit ($p = 0.018$). The subjects that did well on Center the Ball also did well on Circular Pursuit.

PSYCHOMOTOR TESTS -- PC- BASED DRIVING SIMULATOR : There was a significant correlation (Pearson's r) of -0.55 between the mean distance on Circular Pursuit and the mean percent correct on the

PC-based driving simulator ($p = 0.012$). Subjects that were closer to the ball in Circular Pursuit also had a higher percent correct on the PC-based driving simulator. There was a significant correlation (Pearson's r) of -0.51 between the mean distance on the first session of Center the Ball and the mean percent correct on the PC-based driving simulator ($p = 0.023$). There was also a significant correlation (Pearson's r) of -0.54 between the mean distance on the second session of Center the Ball and the mean percent correct on the PC-based driving simulator ($p = 0.014$). Subjects that were closer to the target in Center the Ball also has a higher percent correct on the PC-based driving simulator.

CONCLUSIONS

In conclusion, none of the psychomotor skill tests or the PC-based driving simulator predicted performance on the ATARI obstacle course. However, Circular Pursuit did correlate significantly with the ATARI motor course. Also, the two psychomotor skill tests correlated significantly with the PC-based driving simulator.

RADIATION DOSIMETRY

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
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Brooks Air Force Base
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August 1995

RADIATION DOSIMETRY

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ABSTRACT

Radiation Dosimetry was the department that I was assisting in. I assisted with the receieving and shipping of badges, (TLD's), that needed to be tested in the reader machines.. Each one was tested for any type of Radiation whether it was internal or external. Rings were also received and shipped out with these badges.

RADIATION DOSIMETRY

Crystal Paz

Introduction

Radiation Dosimetry is basically the study of Radiation an individual has been exposed to over a certain period of time. In order for this to be accomplished, the individuals must wear a Thermoluminescence Dosimeter, (TLD). The individuals that wear these badges, TLD's, are people who work in other bases worldwide. They wear this everytime they are working in the surroundings of Radiation activity. They also use rings consisting a small Lithium Chip inside which is used in the same manner.

Methodology

The method they use to test the TLD's is by using reader machines. The other employees that work in this department put the badges,(TLD's), in trays to put through the reader machines. The contractors that work with the reader machines sort out the badges that are high exposures or that have failed. Rings are read basiclally in the same process except the chip is read itself. The rings are replaced with a new, clean Lithium Chip before they are shipped out. After this is done, they are shipped out to the different bases that they belong to. Each base has a base code in order to distinguish which badges or rings belong to a certain individual. I was involved in shipping them to the bases and making sure they received the right amount of badges and rings.

Conclusion

In conclusion, my experience here has been very educational. I have learned and observed how the TLD's and rings are read and how important they are. I have also learned the different types of radiation a person may come in contact with. I enjoyed learning new things and intend on participating in this program next year.

Associate did not participate in program.

Video Imaging of a Plasma Shockwave in Water

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
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and

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August 1995

Video Imaging of a Plasma Shockwave in Water

David S. Rosenberg
Dr. John Taboada

Abstract

Laser generation of plasmas is of growing importance in surgical applications. We have studied the development and propagation of a plasma shockwave in water using a self-strobing technique. A previous study by Fujimoto and others used time-resolved spectroscopic techniques to investigate the dynamic behavior of plasma shockwaves. Where as that method required the averaging of data from numerous plasma events to obtain a composite image of a shockwave, our method can get a complete image of a plasma shockwave from just one event. From several images over time we can obtain information about the velocity and acceleration of the shockwave.

Video Imaging of a Plasma Shockwave in Water

David Rosenberg
Dr. John Taboada

Background

A plasma can be formed by superheating matter with a focused laser beam. A plasma acts as a hot gas and expands forcefully upon formation. The sudden expansion of the gas causes a shockwave surrounding the plasma. For surgical applications, it is worthwhile to know the characteristics of this shockwave to determine what effects, if any, it may have on the tissue surrounding the ablation.

Objective

The objective of the project was to study the propagation of a plasma-induced shockwave in water. Specifically, we wanted data on the velocity of the shockwave propagation over time.

Methodology

An Nd:YAG laser, which generates plasmas with a focused beam of 1064nm light, was positioned so that its beam focused inside a cuvette of water. A microscope was setup perpendicular to the laser beam such that its field of view contained the focus of the laser beam. A CCD camera was attached to the microscope eyepiece by a specifically designed interface tube. A 1.1 micron band pass interference filter and 2 neutral density filters were placed inside the tube for an overall intensity reduction of approximately 4 OD. The filters decreased the video saturation from the bright light of the plasma event. Another measure taken to minimize the saturation of the video camera as well as to decrease the likelihood of multiple plasma events from a single laser shot, we adjusted the YAG laser to the lowest energy level at which a plasma could be consistently generated in water. A VCR was connected to the CCD camera to serve as a recording device.

In order to get a visual image of the shockwave a specific time after the plasma formation, we used a technique of self-strobing. A fraction of the laser light was diverted between the focus and the laser with a beamsplitter. The beamsplitter consisted of a thin glass slide and was placed approximately 70 degrees from the laser beam. The reflected light was focused into a fiber-optic cable, which served as a delay loop for the light. In order to analyze the propagation of the shockwave over time, two different length fiber-optic cables were used. First a 10 meter cable was used, then a 5 meter cable. The light exiting the fiber was directed toward the microscope such that it would pass through the focal space of the microscope. Images of the plasma without the strobe and images of the strobe without the plasma were recorded as controls for comparison with the strobed plasma images. The control images were obtained by blocking the light at appropriate points along the optical path.

Results

The YAG laser energy level was set at approximately 7mJ. Plasmas were generated in water approximately 80% of the time at this energy level. The image of the strobe without the plasma is shown in Figure 1. The speckle pattern of the light is a characteristic of laser light illumination. An image of a plasma without the backlight is shown in Figure 2. The largest white area is the main plasma event. We suspect that the other white spots are either illuminated debris or secondary plasma events. A representative image of a plasma with backlighting and a 10 meter delay cable is shown in Figure 3. A backlit plasma with a 5 meter delay cable is shown in Figure 4. The average shockwave radii with a 5 meter delay cable and a 10 meter delay cable were approximately 350 microns and 550 microns respectively. These figures were obtained by measuring the shockwave images and adjusting for a 120 times magnification. The speed of light through the cable was approximately 0.69c. Thus the wave propagation velocities at 25ns and 50ns

are approximately 14,463 m/s and 11,387 m/s respectively. Both of these results are supersonic and much faster than we had expected.

Discussion

The plasma shockwave was recorded in our images as dark circular areas surrounding the main plasma event. We suspect that as a shockwave passes through a given volume of water, it changes the water's index of refraction. Assuming that shockwaves propagates approximately spherically, we suspect that the shockwave acts as a lens. Thus the strobe light passing through the shockwave would be focused outside the focal volume of the microscope. What we are actually imaging is most likely a shadow of the shockwave. It is possible that the light exiting the fiber optic delay cable may not have had all the characteristics of laser light. For example, the end of the delay cable may have acted as a point source, emitting a cone of light. If this was the case, then the values calculated for the shockwave radii and velocities were larger than the actual values. Another factor that may need to be accounted for is the magnification effect of the water in the cuvette. If the water effected significant magnification, then our results are larger than they should be.

Conclusions

Our results suggest that a self-strobing technique is effective in imaging a plasma shockwave. To have a more complete picture of the propagation of the shockwave over time, images would have to be obtained using a greater number of different length delay cables.

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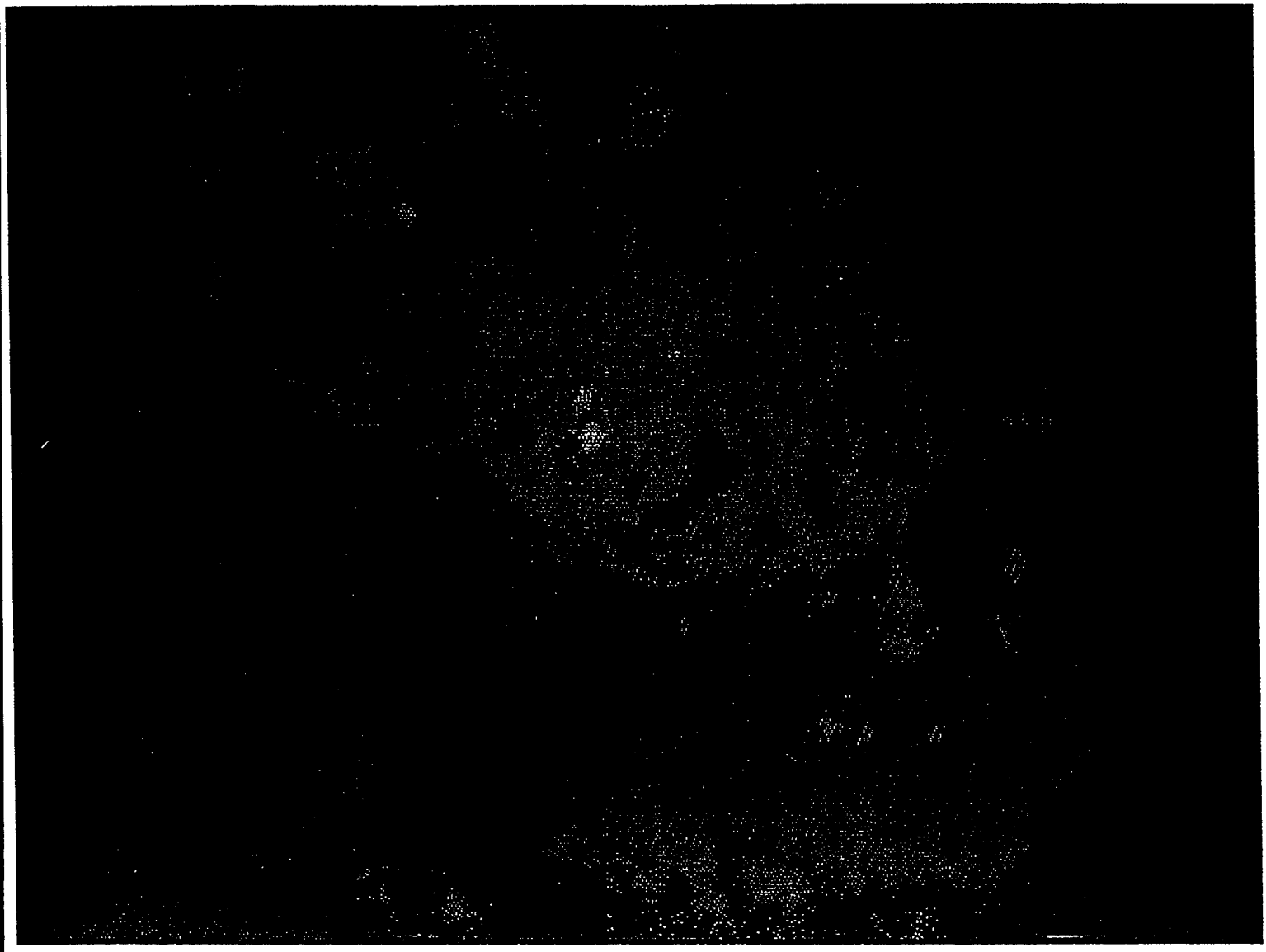

Figure 1

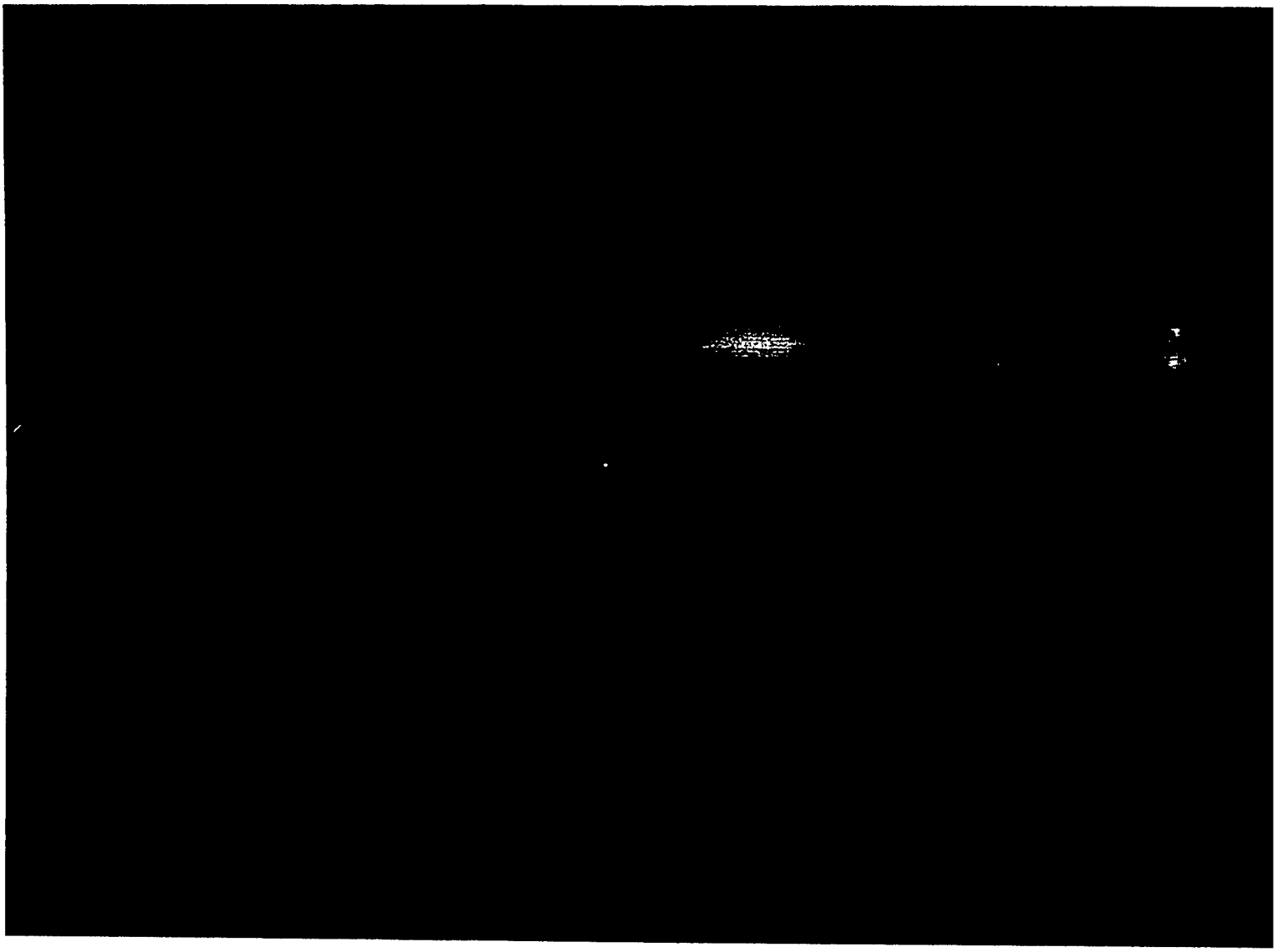

Figure 2

Figure 3

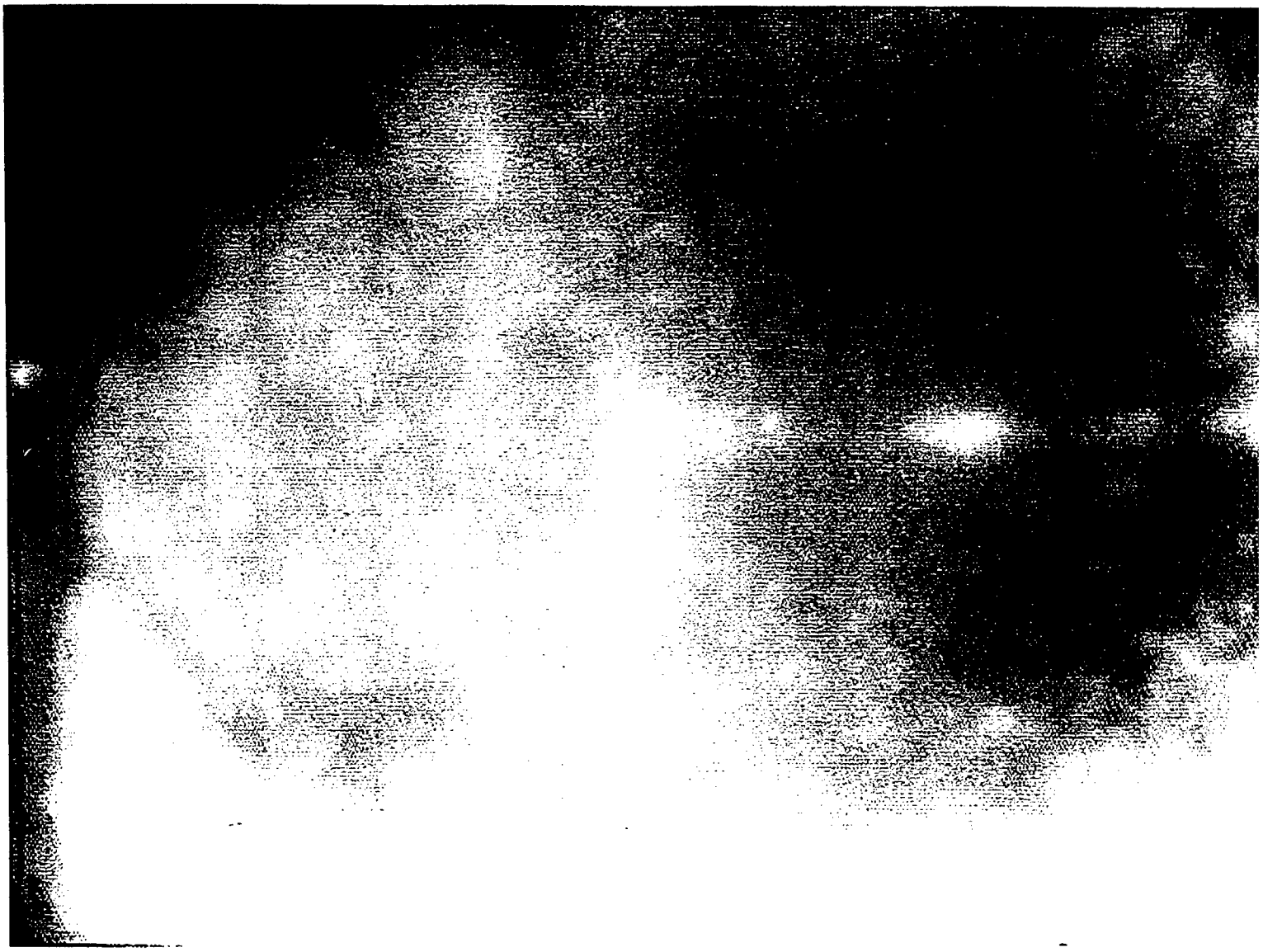

Figure 4

A STUDY OF FITTS' LAW ON THE PHPANToM™ HAPTIC INTERFACE

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Final Report for:
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August 1995

A STUDY OF FITTS' LAW ON THE PHANToM™ HAPTIC INTERFACE

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Greenon High School

Abstract

Fitts' Law was studied on the PHANToM™ haptic interface. First a virtual task board was constructed to demonstrate Fitts' Law and lay the foundation for future experiments. The task board simply consists of a wall with cylinders protruding out of it. A subject was instructed to touch the top of one cylinder and then the top of the next. The time it took to complete this task along with the diameter of the cylinder and the distance between them was used to compute the subject's capacity (bits/second), which is a measure of human performance. Results prove that a Fitts' Law task can be done on the PHANToM™ and ideas for future experiments have been formed.

A STUDY OF FITTS' LAW ON THE PHANToM™ HAPTIC INTERFACE

T. Travis Ross

Introduction

Telepresence is the idea of having a teleoperator control a slave, namely a robot, in a remote or dangerous environment and having the human operator be able to see, hear, and feel what the robot sees, hears, and feels in the remote environment. One device that allows the user to feel virtual objects is the PHANToM™ (Figure 1). The PHANToM™ is a force reflecting haptic interface[1]. It finds the x, y, and z coordinates of a point inside a virtual environment. The point is the user's finger that is inserted into a thimble. This thimble is attached to a gimbal that allows free orientation (pitch-roll-yaw) movement of the finger tip. The gimbal is attached to an arm that also has a full range of motion. At the other end of the arm are three motors that exert a force if the thimble penetrates a virtual wall. One can also place virtual objects in the box. Spheres, cubes, and even more complex objects feel as real as if they were there. The objects can also be manipulated. A sphere may be rolled along the floor, or a cube can be bounced off a wall.

Fitts' Law is a way of measuring human performance on a certain task. It was invented by Lt. Col. Paul M. Fitts between 1955 and 1959 at the Armstrong Lab. It is measured in the relationship of accuracy and speed at which a task is done. These are two very important things in a telepresence environment. The more accuracy one uses, the more one's speed decreases. The more speed one uses, the more one's accuracy decreases. The reasoning behind this is that the more accuracy a task requires, the more one must process things in his/her mind and make minor motion adjustments, therefore slowing one down. If one forces a task to speed up, accuracy is lost. Using Fitts' Law the difficulty of a simple task can be measured. Fitts' Law can be measured by a tapping task or a peg-in-hole task. One example of a peg-in-hole task is the task board constructed by the Naval Oceans Systems Center (NOSC)[2]. It consisted of a large board with several holes into which pegs of various diameters can be inserted. The larger the peg, the more difficult the task becomes. These tasks can be done by hand, or a seven-degree-of-freedom force-reflecting exoskeleton can be used to impede or enhance performance. This exoskeleton can also be used to control a slave robot arm, and have it do the tasks remotely. This best represents telepresence. A tapping task is simply touching a home area then touching a target area. The difficulty of the task can be varied by either moving the home and target closer or farther apart, or changing the sizes of the areas. The formula to measure difficulty is $ID = \log_2 2A/W$ (bits/response) where ID is the Index of Difficulty, A is the distance between the starting position and the target, and W is the difference in size between the target and the user point. A person's performance or capacity can be measured by dividing this by the time it took to complete the task. These tasks can be done using a simple tapping task or a peg-in-hole task.

The goals set were to construct a virtual Fitts' Law task board on the PHANToM™, prove that Fitts' Law could be done on the PHANToM™, and form a basis for future experimentation.

Methodology

Using the NOSC task board as a model, I constructed a virtual task board in the PHANToM™ virtual environment. At the beginning of a run two circles appear on the display screen. One is yellow. One is green. The subject's finger is represented by a cursor on the screen. In the virtual environment two cylinders are constructed on the back wall of a virtual box, corresponding with the circles on the screen. The size of the cursor does not need to be changed since the size of the cylinders can be changed to change the difficulty of the task. The subject must then touch the top of the yellow or home cylinder and then, as quickly as possible, touch the top of the green or target cylinder. The time between the home and target, which does not start until the user's finger is off the cylinder, is recorded by the computer so that it can be entered into the Fitts' Law formula. Then two new cylinders are constructed in new locations. This changes the difficulty by altering the distance between the cylinders. This procedure is repeated 10 times, then the size of the cylinders is changed. There are three different cylinder sizes, varying from .24 cm to .60 cm. Therefore, there are 30 trials per run in addition to two practice trials at the beginning of each set of 10. The practice trials allowed the subjects to adjust to the new cylinder size.

Six coworkers and I were chosen as subjects. They consisted of five males and two females with ages ranging from 16 to 52. Most of them had used the PHANToM™ before, but only one had used the PHANToM™ more than a few times. Each subject ran for 15 minutes a day, with the number of runs ranging from three to seven depending on the speed at which the subject performed, and the number of days ranging from five to eight. The last three days were taken as data. Each subject gave 15 runs as data.

Results

The results for each run from the three data days were averaged and then graphed. These graphs greatly resemble the graphs from the real NOSC task board, as can be seen by comparing Figures 2 and 7. They are also linear. This shows the consistency of the virtual task board and Fitts' Law. The graphs of each subject's time compared to the difficulty of the task (capacity) can be seen in Figures 3 through 8. The subject's capacity from day to day varied as would be expected, but on average rose steadily as can be seen in Figures 15 through 20. The subject's capacity from run to run also varied, but again rose steadily as the subject learned as can be seen in Figures 9 through 14. There also seemed to be a trend that the higher the capacity, the higher the standard deviation, as can be seen in Table 1. Using these results as a foundation, future experiments can be done. All of the goals were achieved.

Table 1

Subject	Three day average capacity	Standard deviation from run to run on last three days
Barry	2.0137	.7141
Chris	2.2604	.7136
Travis	3.0684	.8146
Angie	.9168	.2618
Dan	1.0043	.5213
Melanie	1.6978	1.3107

Conclusion

From the results a conclusion can be made that a Fitts' Law task can be done on the PHANToM™, so that in the future more complex experiments can be done. I am currently working on a damping field that will slow the finger down as it approaches the target. This can be used to eliminate slight errors in the subject's movement. Other ideas such as display gain also surfaced. What would the result be if a subject moved his/her finger one inch in real space, but the cursor moved two inches on the display screen? Or if it only moved a half of an inch? There are certainly many other things that need to be researched.

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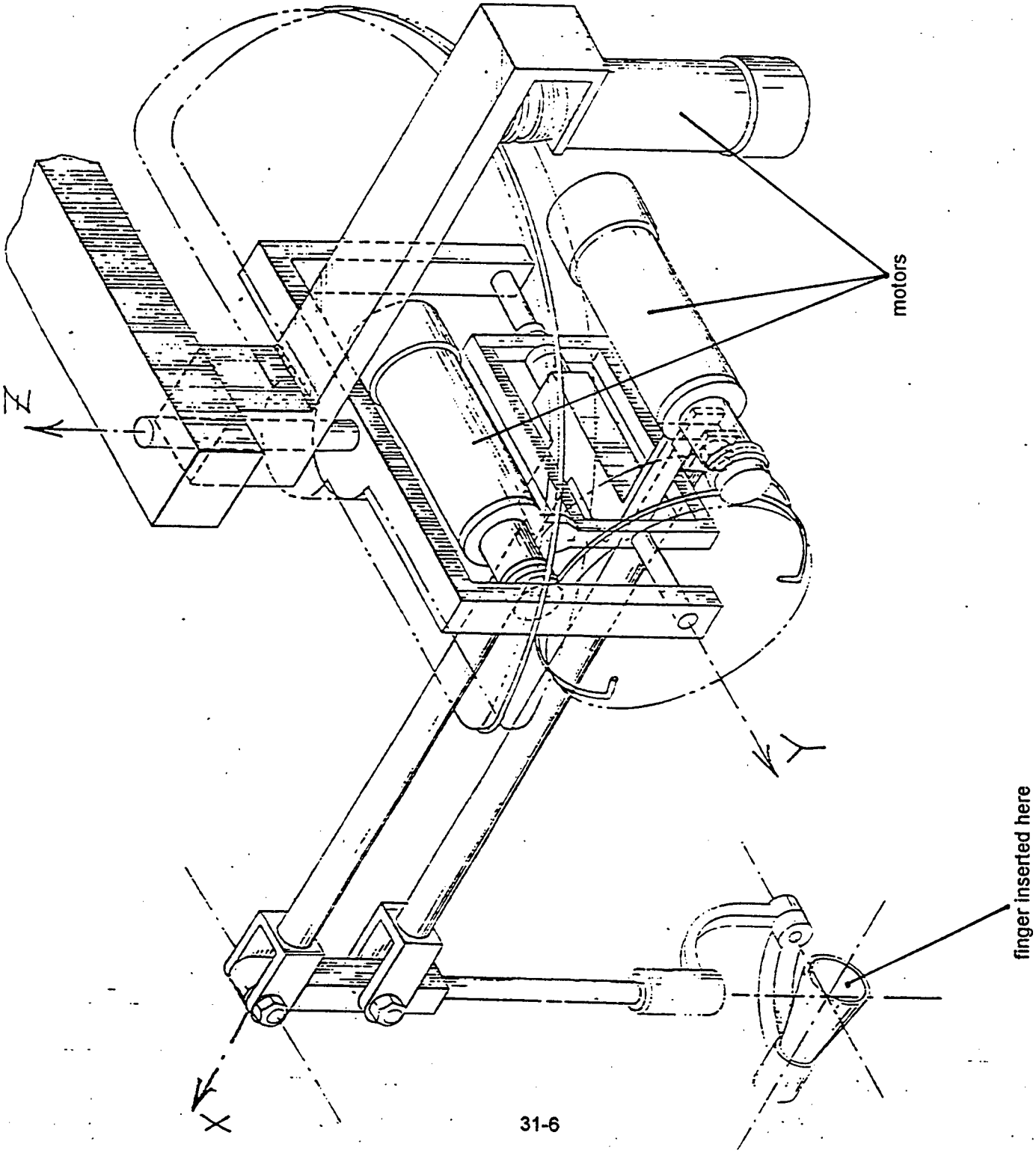
Figure 1



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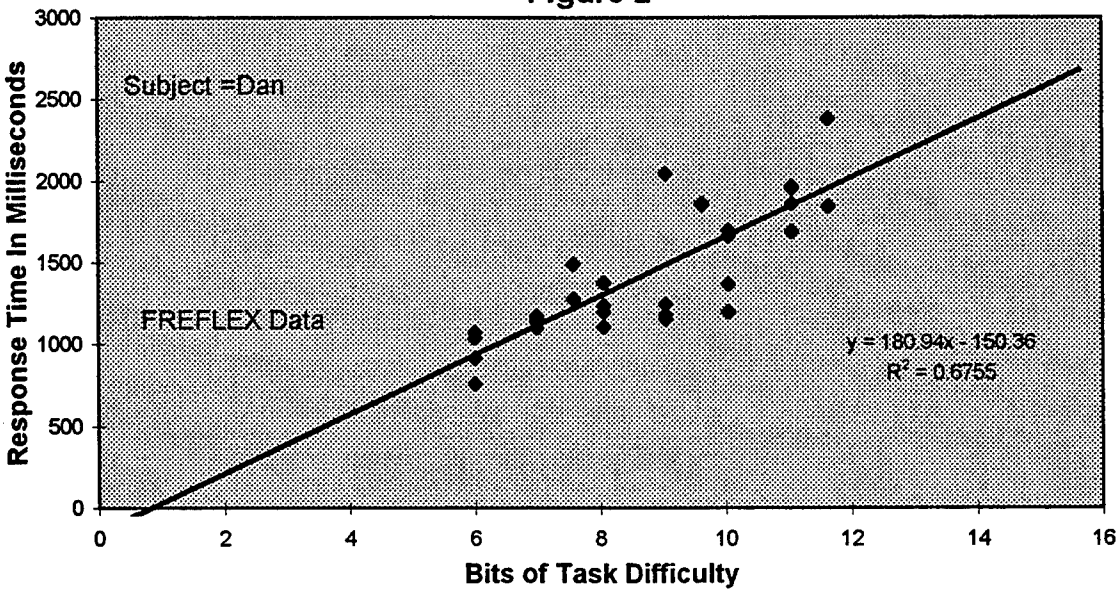
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FREFLEX Data
y = 180.94x - 150.36
R² = 0.6755
Response Time In Milliseconds
Bits of Task Difficulty
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2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16

Figure 3

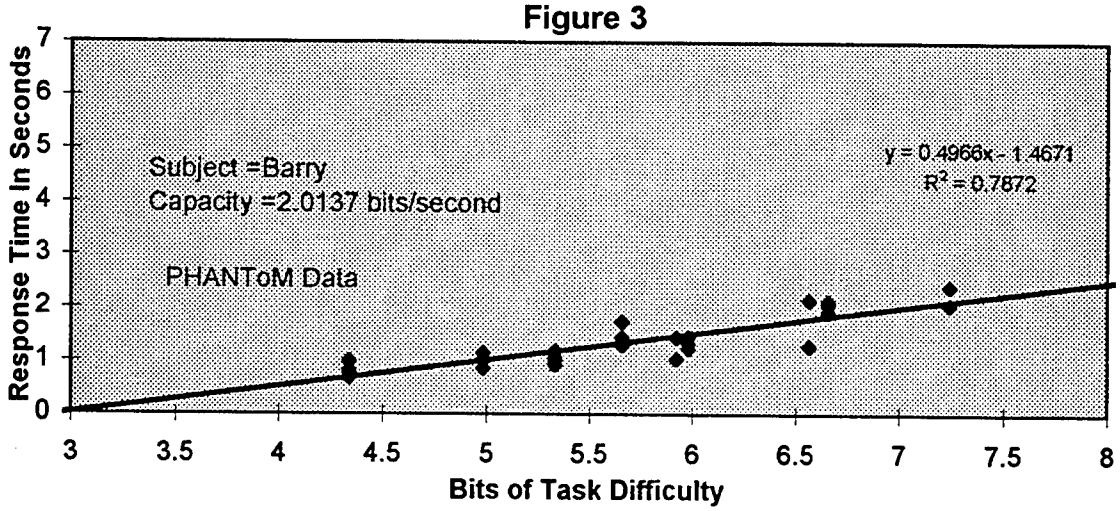
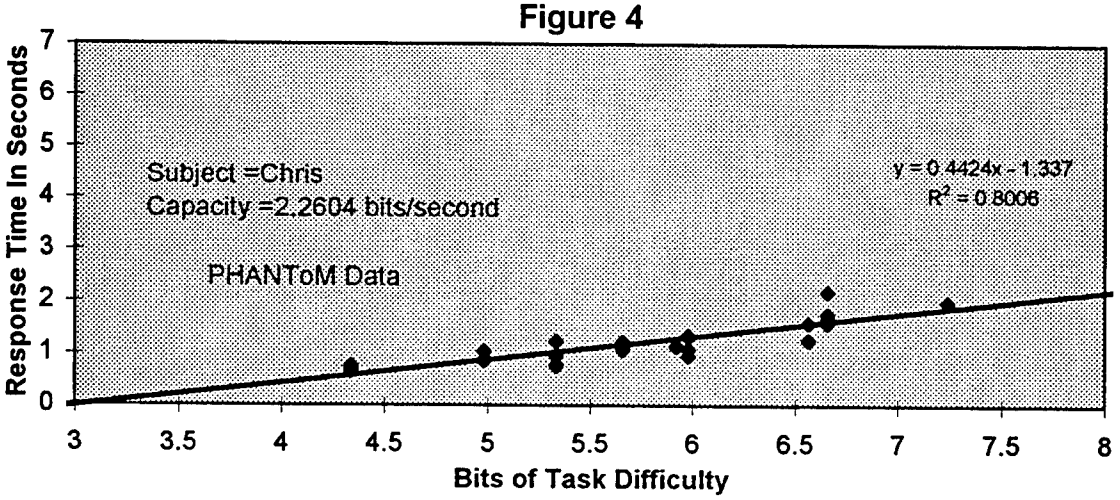


Figure 4



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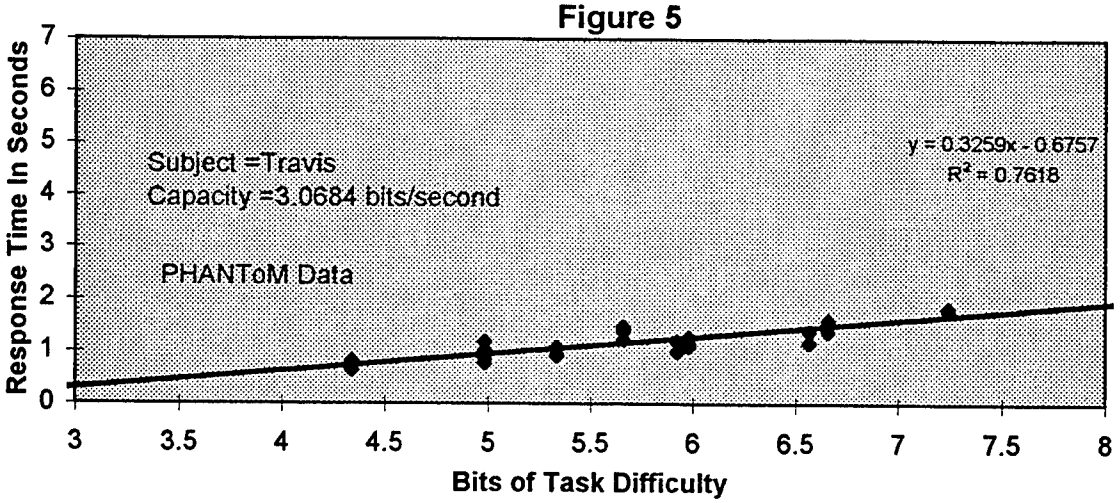

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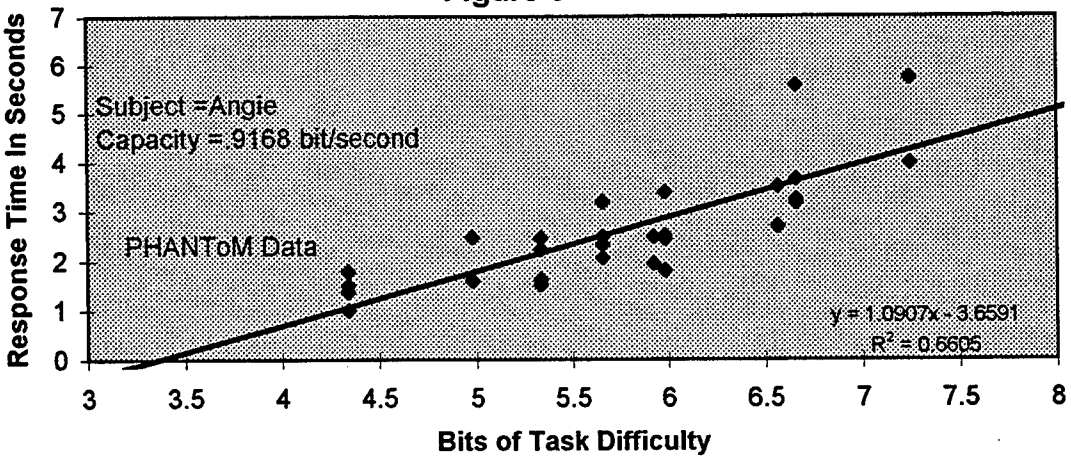

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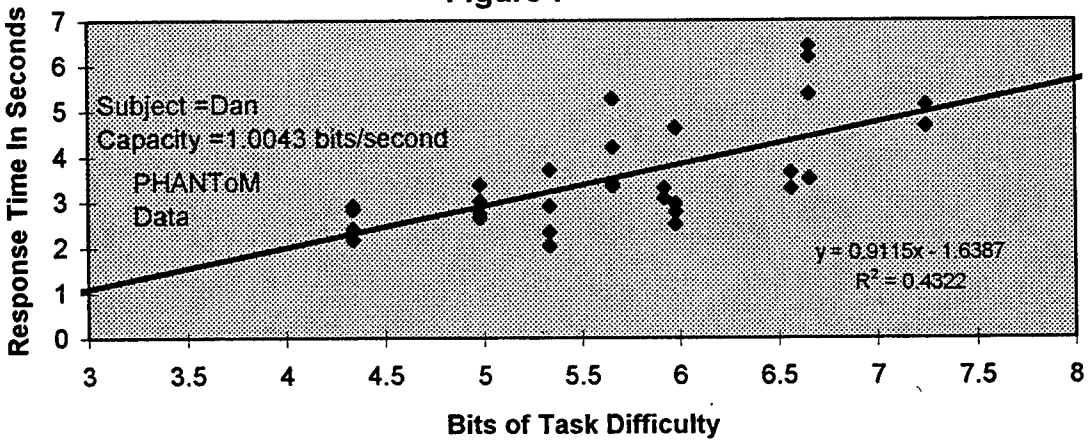

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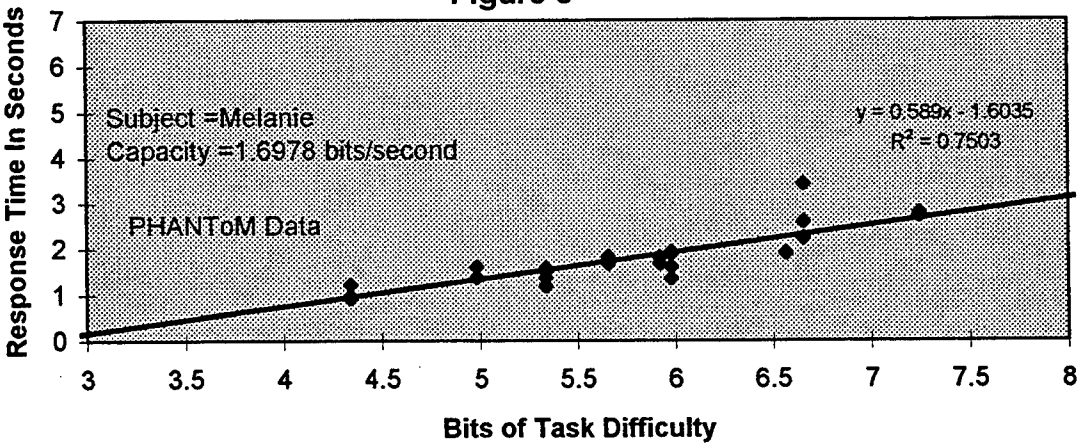

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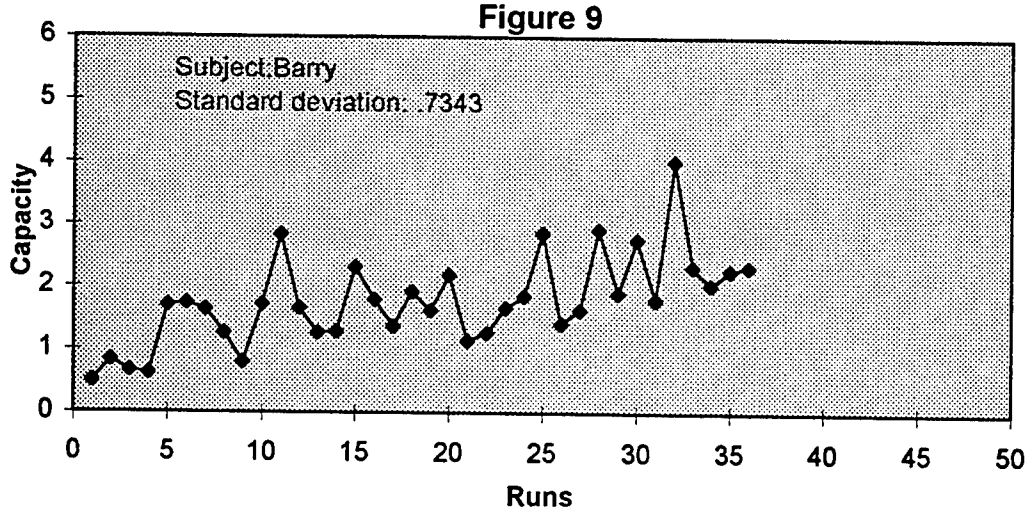

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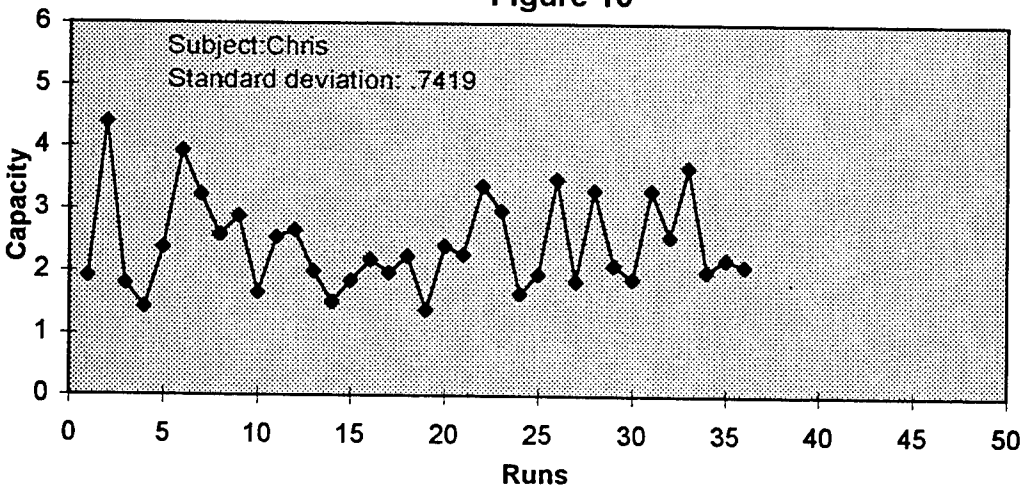

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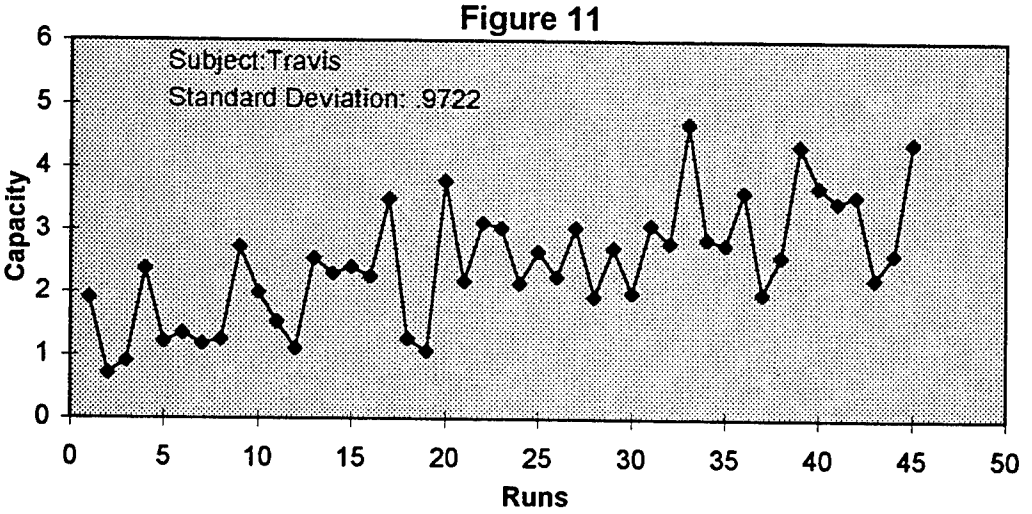

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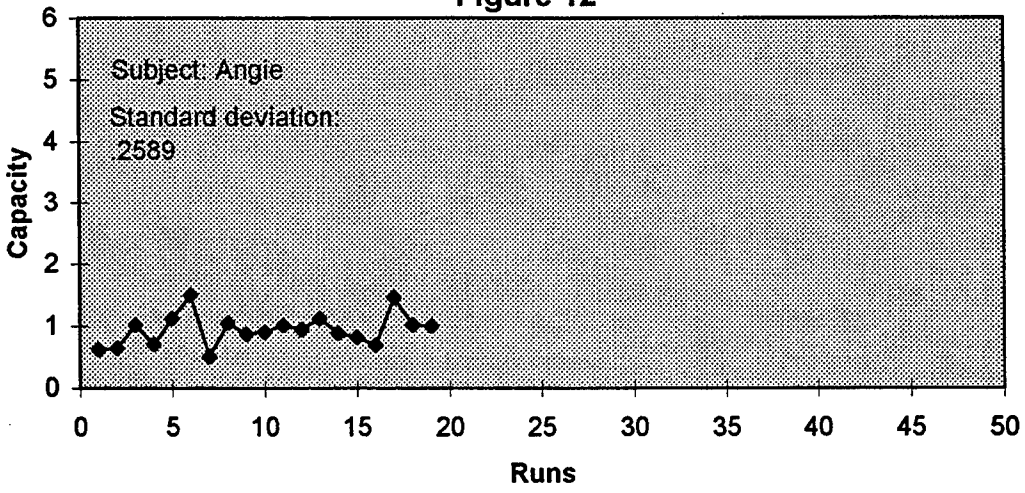

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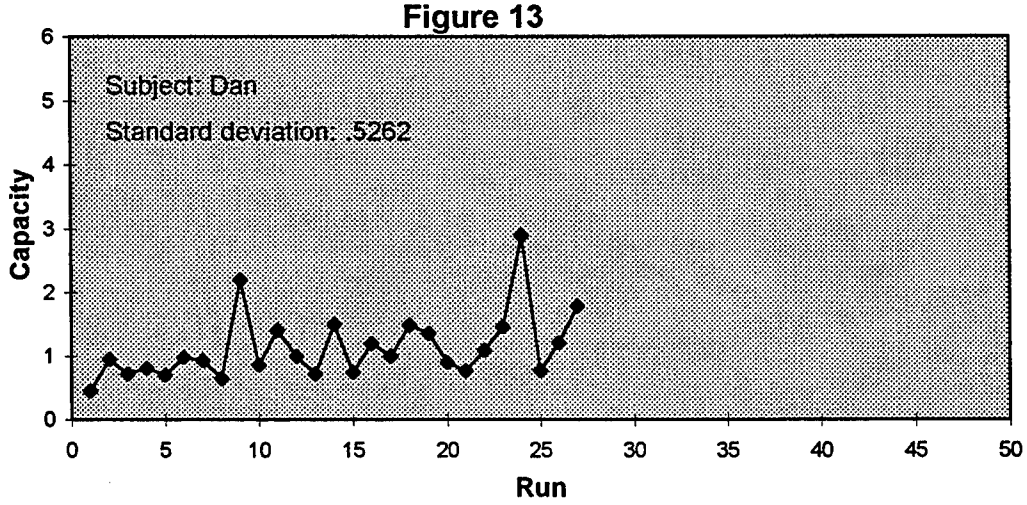

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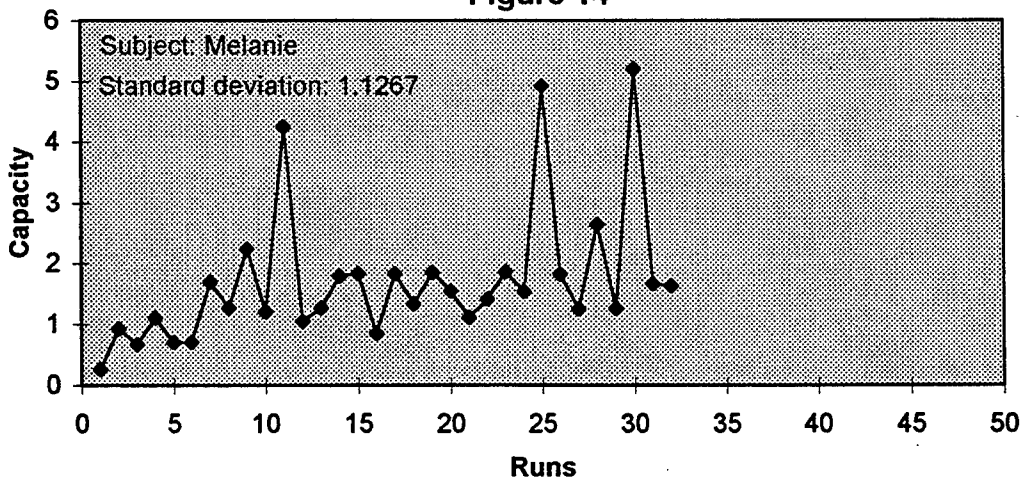

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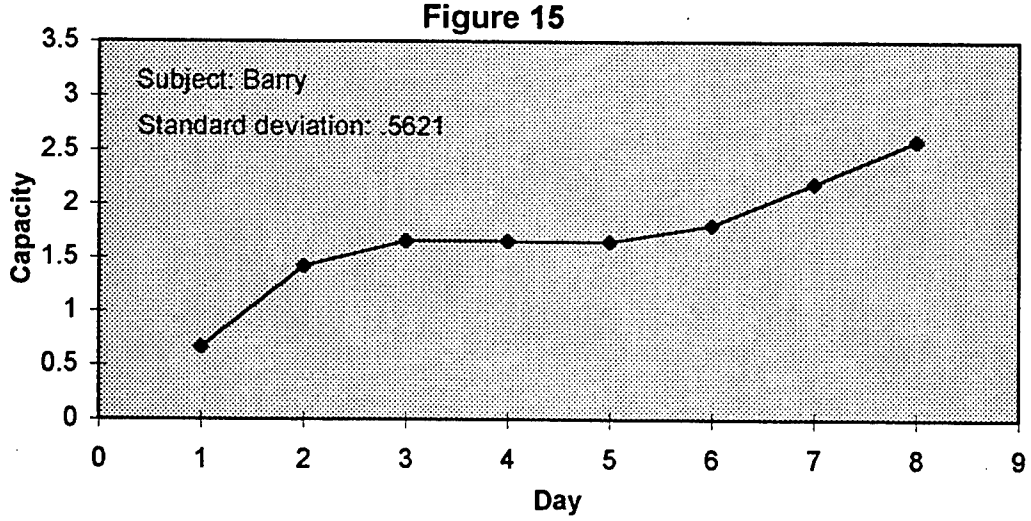

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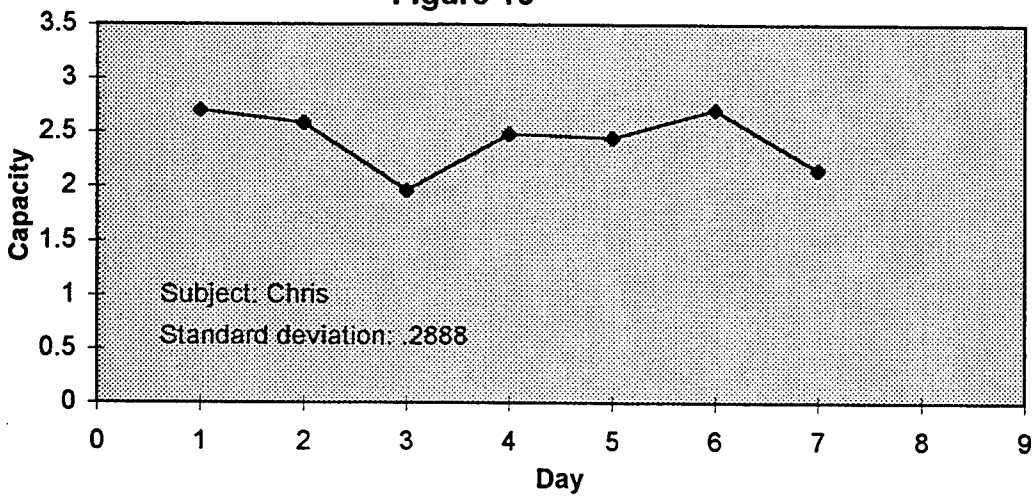


Figure 17

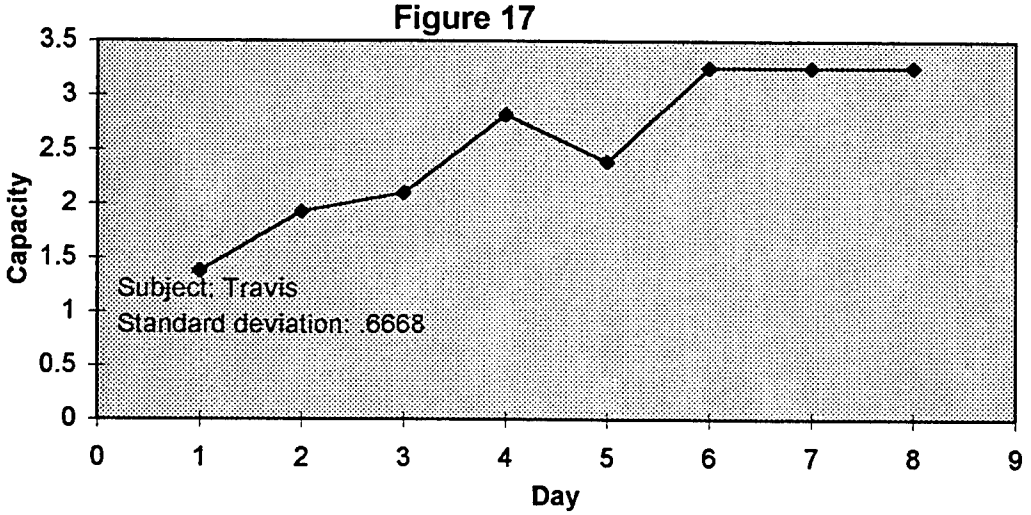
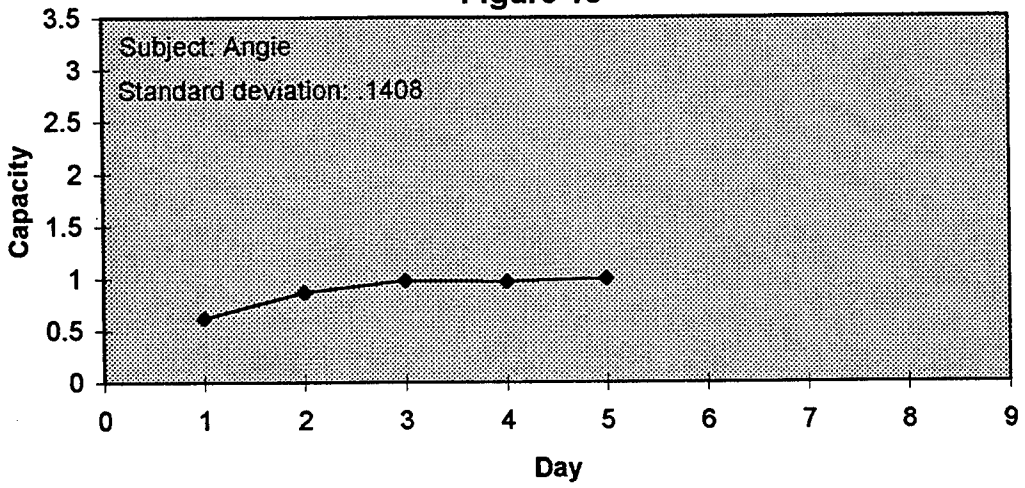


Figure 18



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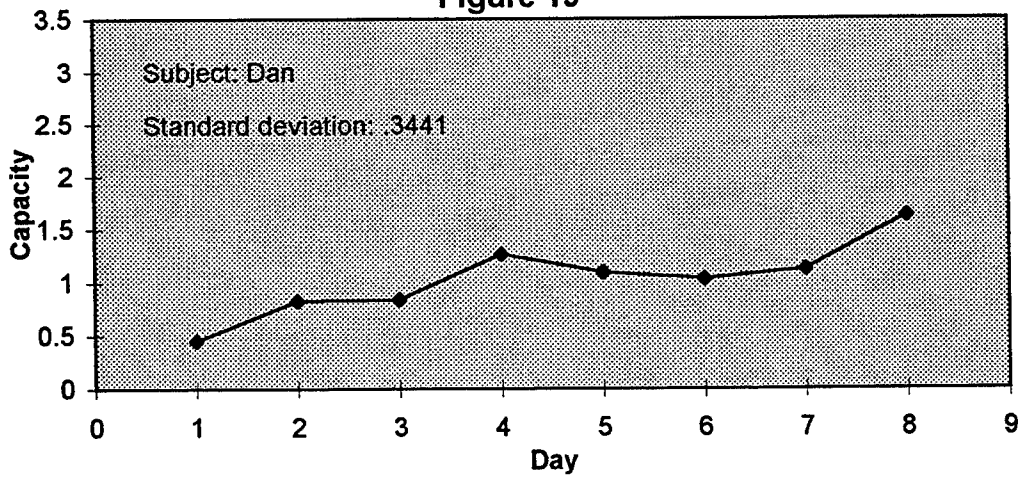

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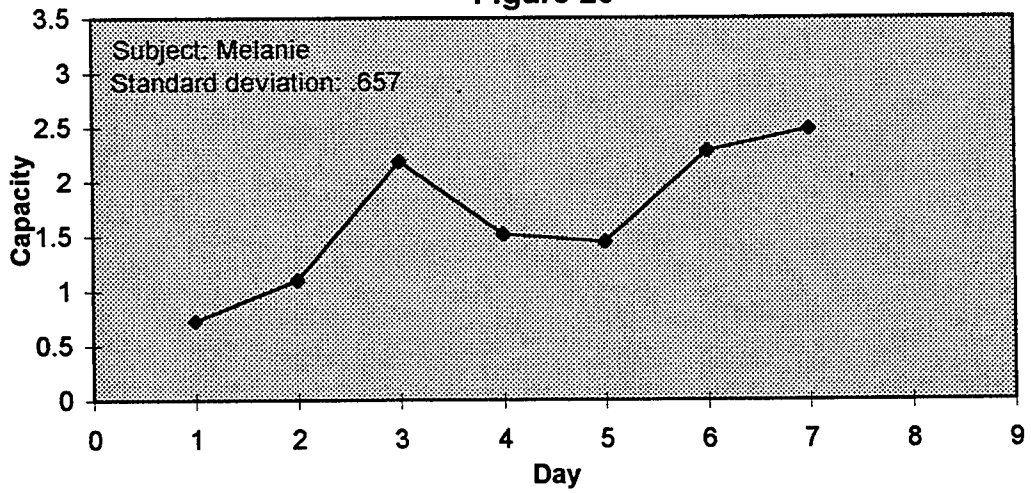

THE RELEVANCE OF HYPERBARIC OXYGEN THERAPY IN SPORTS MEDICINE

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Final Report for :
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August 1995

THE RELEVANCE OF HYPERBARIC OXYGEN THERAPY IN SPORTS MEDICINE

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Abstract

Hyperbaric Oxygen Therapy has been used for some time as a treatment for non-healing wounds and for Decompression Sickness (DCS). It is by no means a new form of medicine, and yet it has just recently been looked at as a possible aid for injuries resulting from sports. Due to time constraints, no lab time was allowed for this project, but extensive research was done, several opinions were sought, and a hypothesis was formed. This paper gives a well defined reason for more research to be done into the area of hyperbarics in sports medicine.

THE RELEVANCE OF HYPERBARIC OXYGEN THERAPY IN SPORTS MEDICINE

Rebecca J. Scheel

What Is Hyperbaric Oxygen Therapy?

Hyperbaric Oxygen Therapy (HBOT, or more recently HBO) has been used for over three centuries, when it was discovered by a British physician, as a method of increasing the amount of oxygen a wound receives. Now HBO is used for treating so many different ailments that no matter what a physician's specialty is, he or she may very well find that they are treating a patient undergoing hyperbaric treatments. When a patient is treated using hyperbarics, they are placed in a chamber, either a monoplace where they need no mask to administer the 100% oxygen, or in a multiplace chamber where they need a hood or a mask to administer the treatment. A patient is given intermitent periods of oxygen with "air breaks" in between. If they were left on oxygen continuously, it could become toxic. Some of the more common indications for hyperbaric treatment are decompression sickness (DCS), carbon monoxide poisoning, osteoradionecrosis, compromised skin grafts or flaps, crush injuries, and other acute traumatic ischemias.

The reason HBO has become such a big discovery is because it increases the healing rate of a wound dramatically. HBO increases the vascularization of the tissues in our bodies. By doing this, it also increases the amount of oxygen a wounded area receives. Not only that, it also increases the concentration of oxygen in the blood. Your blood does not need more hemoglobin to accomodate this function. In any wounded area of the body a hypoxic environment develops. Swelling increases, circulation decreases, and necrosis begins. It is a vicious cycle, and the damaged area needs oxygen to remedy it. When circulation gets decreased due to the swelling, oxygen is one of the necessary elements that gets cut off. HBO helps to avoid that. Hyperbarics also helps re-absorb the bodies fluids back into the tissue, thereby reducing the swelling. That is where is comes in handy for DCS cases. HBO re-institutes the bubbles in the blood back into the tissues. The bubbles get smaller due to the pressure being exerted on them and soon disappear. Though it seems as if HBO can do no wrong, there are some uses for it that are still under a great amount of scrutiny. Some of these are injuries acquired in sports, sickle cell anemia crisis, cerebrovascular accidents, multiple sclerosis, closed head injury, and several more.

Some of the Injuries Encountered in Sports Medicine

HEAD TRAUMA

Head trauma occurs in a great many activities but it is prevalent in sports. Approximately 1%-9% of all injuries in high school football are head traumas, and 2.9%-4.5% of collegiate football injuries are to the head. 40% of injuries in boxing and 28% in golf are to the head. Some of these are more serious than others causing convulsions and prolonged unconciousness, but the great majority are less serious. They may have prolonged periods of unconciousness, but they are usually recuperate quite well on their own when given the time. HBO, however, would help reduce intercranial pressure in the more severe cases. It would also insure adequate oxygenation of the brain, which should be a priority in any head injury.

FACIAL OR DENTAL INJURIES

A large majority of the injuries encountered in sports are to the face or mouth. Scratches are a common occurance. There are 30,000 facial injuries a year in baseball in children, and just as many in adults. In both football and hockey there are 8,000 a year, in soccer there are 4,000, and in biking there is an astounding 106,000 a year. Some of those injuries are mandibular or maxillary fractures, chipped or missing teeth, or hematomas to the facial region. Any type of fracture to the face can take a player out for 6-10 weeks. A missing tooth can easily be dealt with and if treated properly and immediately can be saved.

SOME INTERESTING STATISTICS :

- A soccer player, male or female, is 3 times more likely to suffer a dental injury than a football player.

- Prior to the mandatory mouthguard rule, 50% of all football injuries were orofacial. Since mouthguards are now worn, that has dropped to .5%.

- In a sample population of injured athletes, 40% of the dental injuries were acquired in baseball and basketball because they do not require mouthguards.

- Women in basketball are 15 times more likely to suffer an oral injury than a football player is.

The basis for using HBO in facial injury cases is that it speeds up the process of bone formation. That goes for anywhere in the body. It also reduces edema which a problem in facial trauma.

UPPER EXTREMITY INJURIES

Any injury in the arm can threaten circulation and nerve tissue. Some of the more common injuries to the arm and shoulder are fractures, rotator cuff tears, muscle ruptures, dislocations, and inflammation. With any number of possible complications these injuries could keep an athlete out for 1 week to the rest of the season. HBO helps with these injuries the same way it does facial injuries. It boosts bone formation and reduces edema, but it also insures that the nerve impulses and circulation do not get disturbed. The last thing that anyone wants to have is loss of circulation to their fingers. That is something that an athlete does not bargain for when they injure their arm.

BACK AND SPINAL PROBLEMS

Back and spinal injuries can be anything from a scratch to paralysis, so great care must be taken. A common injury in football is a stinger, or a pinch of the spinal cord that causes the athlete to lose all sensation below his neck for a short period of time. Other common injuries include slipped discs, bruises to the spinal cord, fractured vertebrate, and muscle ruptures. These can be extremely painful. They can be treated any number of ways, but an acute back injury must be treated more carefully than any other injury because they can cause permanent damage. HBO has been shown to help bruises to the spinal cord heal. As has already been shown they improve the rate of fracture healing. Of course, HBO will not help complete lesions of the spinal cord, but it will help partial ones. Any injury to the spinal cord deserves an HBO referral. It could possibly save the player from a lifetime of pain.

LOWER EXTREMITY INJURIES

Just as with the upper extremity injuries, possible nerve and circulation impairment are an important consideration with injuries in the thigh, knee, ankle, and foot, or any other area in the leg. There are a large majority of muscle bruises and ruptures in the thigh in sports. Other common occurances are anterior and posterior cruciate ligament tears. Ankle sprains are also frequent. As can be expected, the bones are often fractured due to the amount

of stress being put on them. HBO helps any one of these injuries by increasing vascularization and new tissue formation in the cases of muscle ruptures, and new bone formation in the cases of fractures. Swelling is also a problem in lower injuries such as to the ankle. P.B. James and his partners performed an experiment. A sample population of injured athletes was studied. 20 minor injuries to the ankle were evaluated by physiotherapists, and, based on their experience, they approximated the period of time it would take for the injuries to heal. They said it would take 210 days combined to heal the injuries. When normal therapy techniques were instituted with the addition of HBO, it took only 63 days for all injuries to heal. This only goes to show that HBO helps heal soft tissue damage, which is what many injuries to the leg are.

Conclusion

In conclusion, through my extensive research through the summer I have come to the belief that hyperbaric oxygen therapy assists in therapy to sports injuries. It helps reduce many of the problems that athletic trainers and orthopedists encounter in treating sports injuries. Soft tissue damage, bone healing, swelling, and nerve and circulation damage are only a few of the things that HBO helps to treat. All of those problems are found when you walk onto the sports field. With what I have found in my research, I find it safe to say that it would be worthwhile to perform further research into this area.

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ANALYSIS OF A POROUS GLASS DIFFUSION CHAMBER

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

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Air Force Office of Scientific Research
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July 1995

33-1

ANALYSIS OF A POROUS GLASS DIFFUSION CHAMBER

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Abstract

A cylindrical chamber containing certain lengths of VYCOR 7930 porous glass tube was studied to determine what effectiveness it would show as a vehicle for diffusion of a liquid yhrough the porous glass into various pressures and flow rates of air through the cylinder. Experimental results showed that this chamber could provide a highly consistent concentration of methyl salicylate that was easily repeatable at different times if the conditions were set to the same values. The concentrations could also be easily manipulated by adjusting the various conditions that the tube operated in. In this way, virtually any concentration into the air flow could be had at most any flow rate.

ANALYSIS OF A POROUS GLASS DIFFUSION CHAMBER

Keith A. Shaw

Introduction

A problem that has plaqued many research experiments is that of introducing a liquid substance at room temperature into a stream of air in a consistent and reliable way. Conventional methods have relied upon a heat source to vaporize the liquid, which is then piped into the air flow. This method does not, however, provide a high degree of consistency over long periods of time. A better way is to use a semi-permeable substance which would allow the liquid to diffuse into the air stream at a constant rate, given the same conditions.

Methodology

The method of diffusion is by inserting a tube of VYCOR 7930 porous glass into a cylindrical metal chamber which carries a controlled and purified air flow through it (see diagram). The glass tube is then filled with the sample liquid (methyl salicylate). The liquid diffuses through the small holes in the glass tube into the air stream flowing through the chamber. This happens in spite of the fact that the pressure inside the chamber is higher than atmospheric

pressure for all tests that were conducted. The output of the device is sent to a gas chromatograph for analysis. Since the unit is generally operated between 50 and 1000 standard liters per minute (SLPM), valves are used to create a 1.00 SLPM flow off of the main output flow which is what is actually sent to the gas chromatograph. In this manner, a one minute external sample can be taken and it will yield the concentration of the chamber output in micrograms per liter. In the test there are four principal variables which can be used to control the output concentration of the substance being diffused into the air stream. They are as follows: inlet pressure, flow rate, cylinder temperature, and surface area of the glass (tube depth in chamber). In order for the results to be accurate and for the experiment to be repeatable, the gas chromatograph must be calibrated for the sample that is being used. Otherwise it will simply yield a value that represents peak response on the graph, which has little value in real-world terms. This is accomplished by using known amounts of the substance that are injected directly onto the sample tube of the chromatograph sampler. The actual amounts each time are then given to the computer so that a calibration curve for that substance can produced. Multiple samples of different amounts are necessary for accuracy (in this case, five were used). A copy of the calibration curve is included with this report. The testing procedure followed the standard

method of maintaining all variables except one in order to determine its effect on the output concentration.

Results

For initial tests, conditions were as follows:

Temperature: 24 degrees C

Tube depth: -11.48 cm

(Note: all depths are negative because amount of tube above the chamber was measured, so amount of tube inside the chamber can be calculated by subtracting from the total tube length, appoximately 26.7 cm)

Inlet pressure: 27.6 psia

Flow rate: 50.0 SLPM

Samples- S128, S130, S132

Concentrations- 6.212, 6.172, 5.929 micrograms/L

Average concentration- 6.104 micrograms/L

For decreased surface area all conditions were the same except tube depth.

Tube depth: -15.26 cm

Samples- S134, S136, S138

Concentrations- 1.690, 1.664, 1.701 micrograms/L

Average concentration- 1.685 micrograms/L

Increased inlet pressure results maintained the second 3test's decreased tube depth.

Inlet pressure- 35.30 psia

Samples- S140, S141, S143

Concentrations- 1.484, 1.527, 1.499 micrograms/L

Average concentration- 1.503 micrograms/L

Conditions from test three, other than temperature, remianed the same.

Temperature- 35 degrees C

Samples- S145, S147, S149

Concentrations- 2.223, 2.201, 2.199 micrograms/L

Average concentration- 2.208 micrograms/L

Only flow rate changed for the fifth test (note that additional energy to the heating coils on the test cylinder will need to be added in order to account for the cooling effect that greater air flow will have, allowing for the same test temperature).

Flow rate- 100.0 SLPM

Samples- S152, S154, S156

Concentrations- 1.224, 1.237, 1.221 micrograms/L

Average concentration- 1.227 micrograms/L

Conclusions

The diffusion chamber idea not only proved itself to be consistent but also able to supply virtually every concentration at many flow rates that could be desired for a test. In order to increase the concentration of the substance being used the temperature can be increased or the tube depth inside the chamber can be increased. To decrease the concentration the flow rate can be increased or the inlet pressure can be increased. This unit was successfully used to test a piece of life support equipment in its ability to filter out contaminants over long periods of time at different concentrations. Its easy repeatability and consistency make it a valuable piece of equipment for a multitude of lab tests.

Figure 1

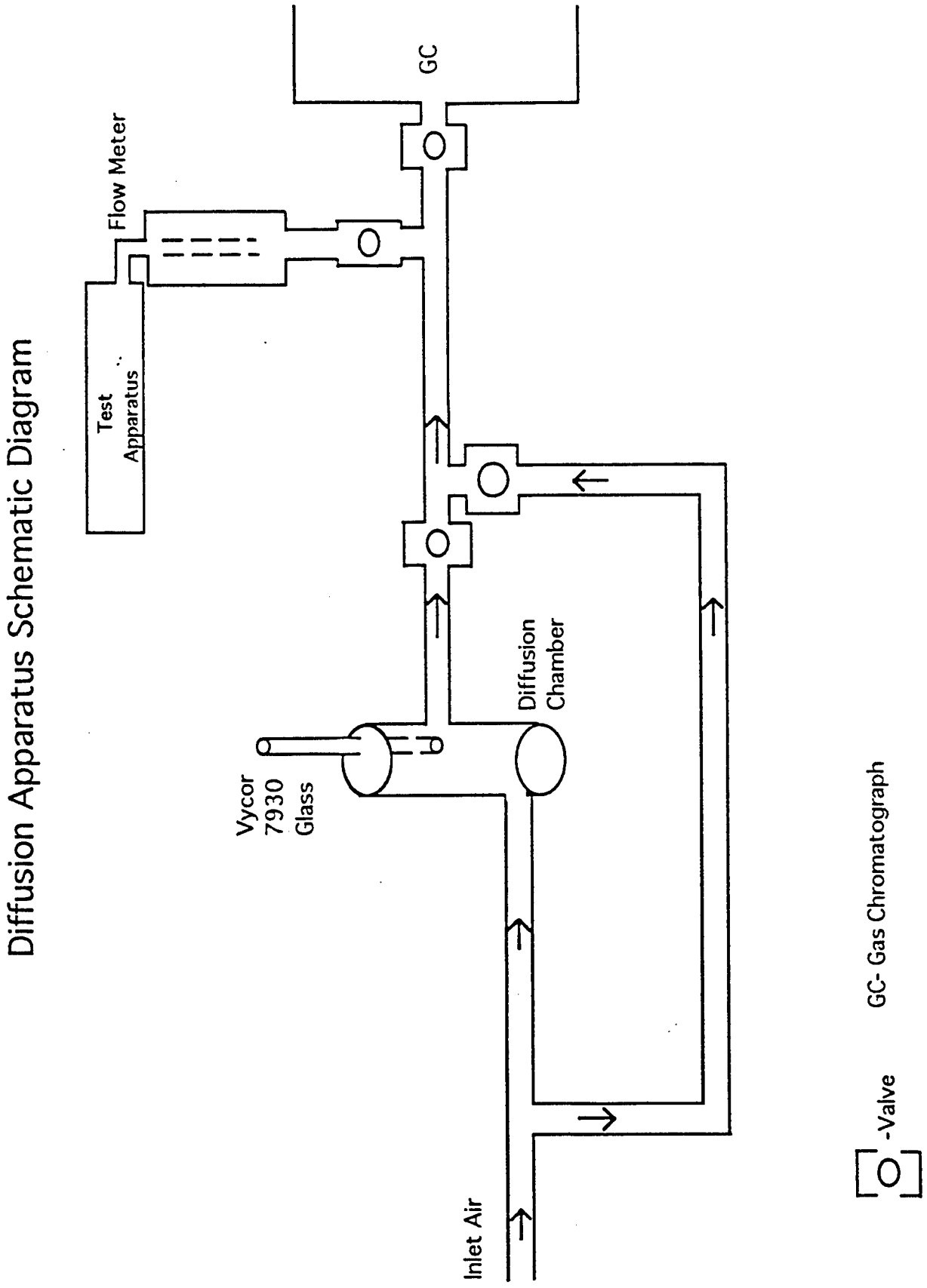
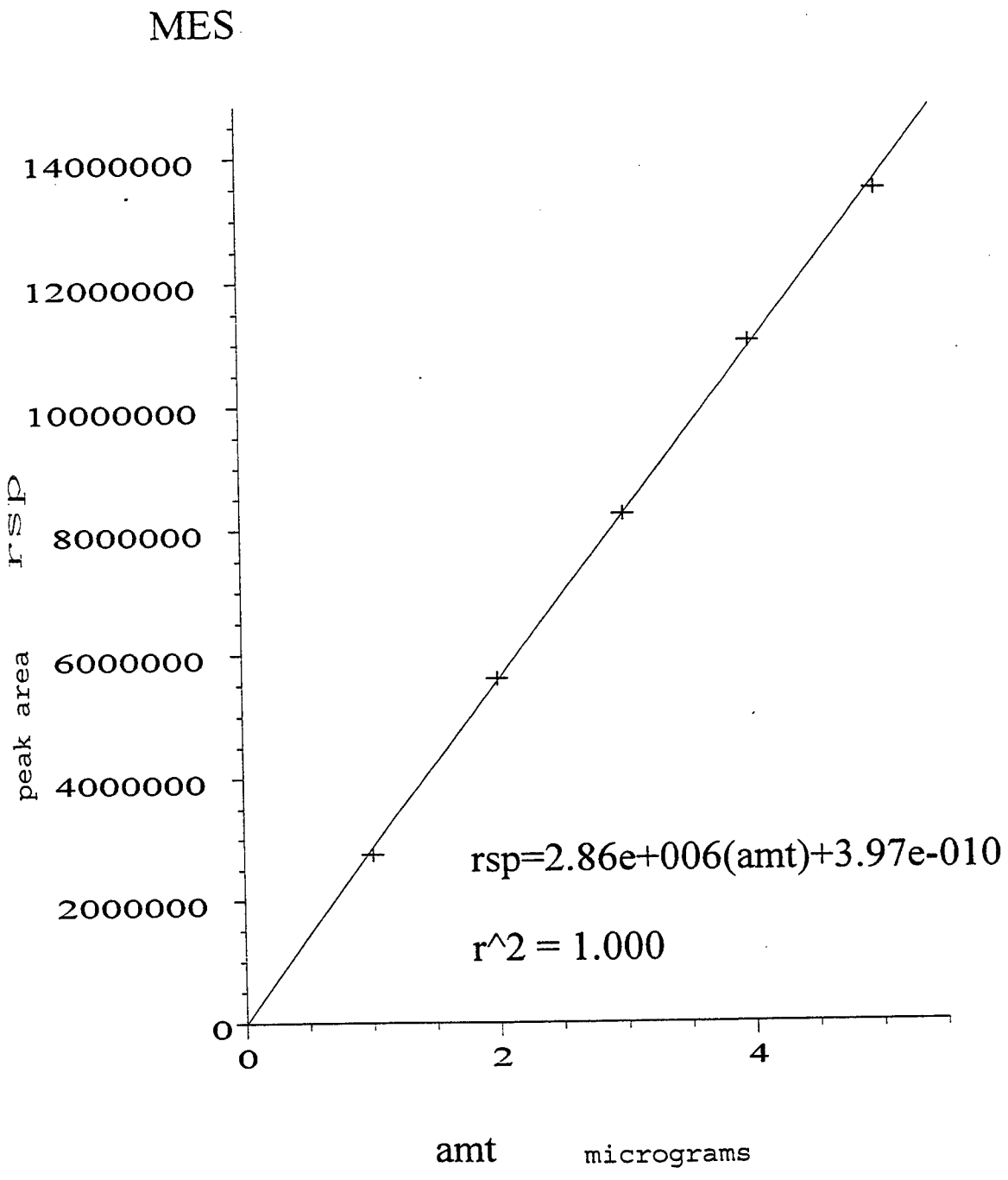

Diffusion Apparatus Schematic Diagram
GC
Flow Meter
Test Apparatus
Diffusion Chamber
Vycor 7930 Glass
Inlet Air
-Valve
GC- Gas Chromatograph

Figure 2

Calibration Curve



* MES- Methyl Salicylate

A Study of the Permeability of Dibromomethane through Butyl Rubber

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Armstrong Laboratory

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August 1995

A Study of the Permeability of Dibromomethane Through Butyl Rubber

Abstract

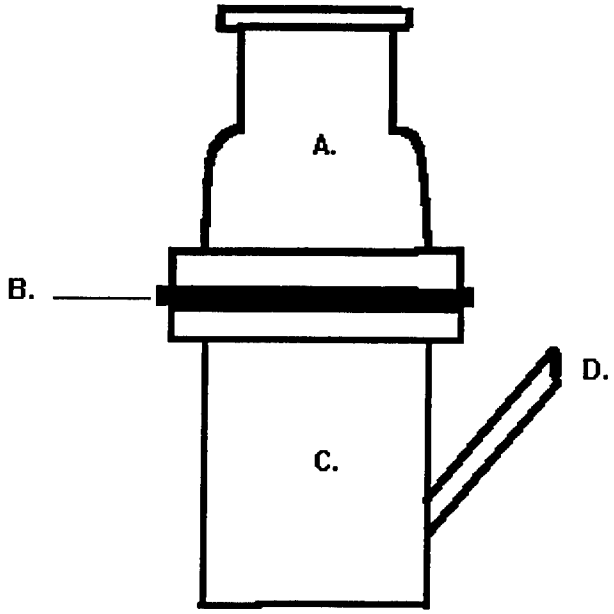
A study of the permeability of dibromomethane (DBM) is being conducted. Fick's Law was used as a basis for experimental design. Fick's Law states that $Flux = \frac{D \cdot K_m}{\delta}(C_{out} - C_{in})$ or $Flux = P \cdot A \cdot (C_{out} - C_{in})$ where D is the diffusivity, δ is the membrane thickness, P is the permeability of the chemical, K_m is the permeability constant of the membrane, and C is the concentration. The common method of using a diffusion cell was used. To begin the experiment a series of standard curves were performed with 20 microliter solutions of 6% volpol saline (a surfactant). Samples were analyzed with a Hewlett-Packard Gas Chromatograph. We measured the flux of DBM through a butyl rubber membrane in the diffusion cell. Once a stable sampling system is established we then plan to use the cell to determine permeability constants for a wide range of industrial chemicals. Once enough data is compiled a mathematical model will be constructed to be used as a tool for estimating flux in a non-steady state conditions. Once a stable sampling technique is established more chemicals will be tested using this system using human skin.

Purpose

This experiment has a unique purpose in that it is a pilot experiment, conducted in order to establish a sampling procedure. In the present and future, civilians and military personnel will encounter countless dermal exposures with many types of chemicals. What is needed is a method of testing the permeability of chemicals in relationship to the human skin as the need arises. This experiment will set up the parameters needed to engineer a system, that provides accurate, reproducible results. It will be important to know the permeability and diffusivity of the various chemicals when trying to determine and design treatment procedures and safe exposure dosage levels . This pilot experiment is necessary to establish an accurate procedure that provides reproducible results.

Methodology

Fick's Law is the principle which describes the penetration of chemicals through a membrane. Fick's Law states that $Flux = \frac{D \cdot K_m}{\delta}(C_{out} - C_{in})$. In this experiment the diffusion cell method for collecting penetration data is utilized. The diffusion cell is comprised of two primary sectors, the receptor sector and the donor sector. These areas are separated by a membrane of butyl rubber. (see figure 1)



A. Donor Half
B. Membrane
C. Receptor Half
D. Sample Access

This rubber membrane can be replaced by skin of laboratory animals or human skin to estimate hazards with dermal contact with chemicals. The receptor half of the cell contains the receptor solution which is a 6% volpol saline solution. Inside this cell is stirring device that is spun by a magnetic stirring bar. This insures an even distribution of

of the diffused DBM. A butyl rubber membrane was placed over the opening in the receptor cell. The donor half is then placed on top of the receptor. All air bubbles are then removed from the receptor half of the cell. In the donor half of the cell, 2mL of DBM is deposited on the membrane. Based on Fick's Law, a portion of the chemical will pass through the membrane from a higher concentration to a lower concentration. Individual experiments last three hours and a 20 μL sample of the receptor solution is taken every fifteen minutes. The 20 μL sample is taken using capillary tubes (micropipets) and gently blown into headspace vials. These vials are equilibrated and analyzed by a gas chromatograph (GC) headspace autosampler. Area counts from the GC are used to calculate the concentration of DBM in the receptor solution. Concentration is then plotted versus time to calculate values in $mg/cm^2/hr$. To obtain as much data as possible, six diffusion cells are used and have staggered start times of one minute.

Along with the actual experiment, a standard curve is for DBM is established. To begin, a 40,000 ppm bag of DBM/Air is made. It is comprised of 4.8 L of air and .569 mL of liquid DBM which once it expands upon vaporization, totals 5.0 liters. The bag is heated to force all the DBM to evaporate and allowed to equilibrate. Ten headspace vials are capped and sealed. Each one is then evacuated beginning with .1 mL and progressing up to 1.0 mL (i.e. .1,.2,.3). Then an equal amount of air from the bag is then injected into the vial. This is done to eliminate the effects of varying pressures in the vials. The standard curve vials are place in the GC along with the other samples.

Once sufficient data is collected other the variables of Fick's Law will be manipulated to produce a spectrum of useable data. This will include different receptor solutions, different concentrations of donor chemicals , and different membranes. The purpose of this is to establish a stable technique for sampling and collecting data. Once a stable system is established different donor chemicals will be introduced and human skin will be used for the membrane.

Results and Conclusions

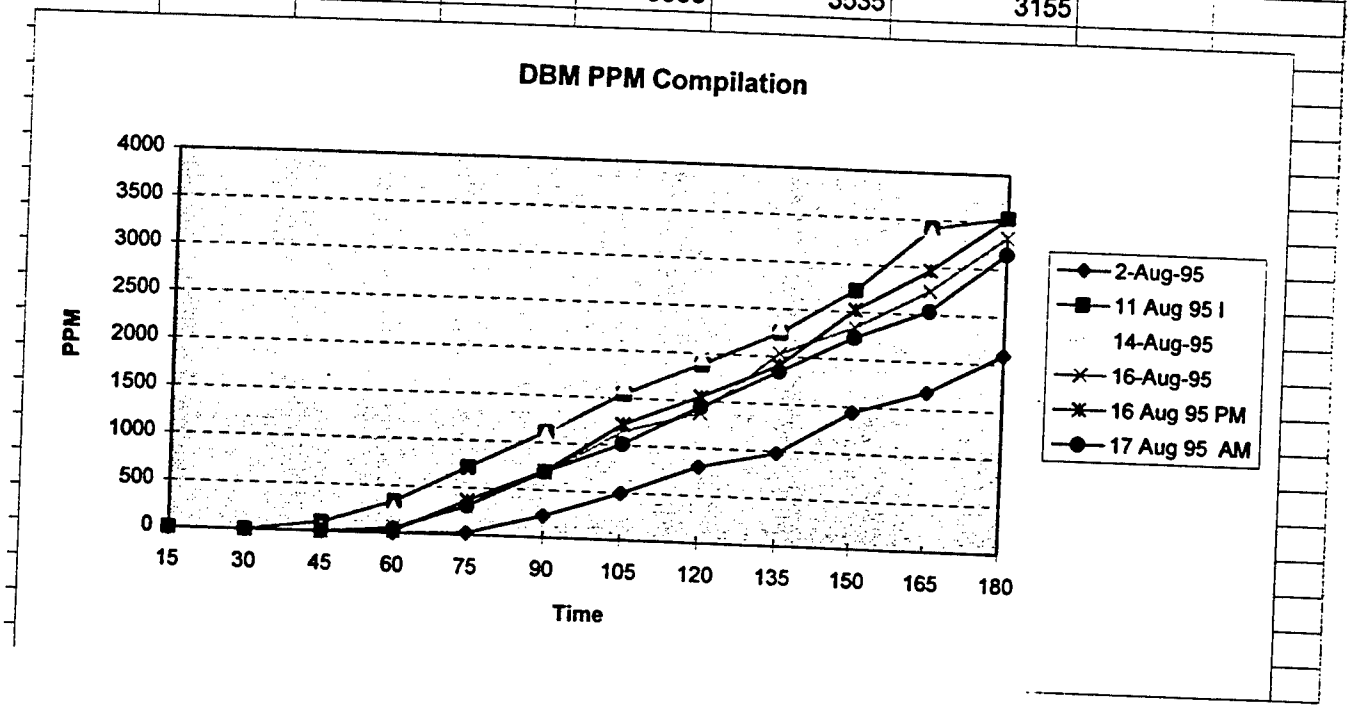
The results of the experiment are very informative. In the cell, the DBM showed what is known as a lag time. No DBM diffused through the cell for at least one hour. Its concentration thereafter increased linearly. Parts per million counts for DBM in the receptor solution ranged 22 to 3538 after the first hour. (see appendix 1) The DBM PPM Compilation compares PPM versus Time. For the standard curve, known DBM in heasdspace vial concentrations ranging from 315.7 ppm to 3157.1 ppm were compared to the area count output of the GC. (see appendix 2) From the equation of this line we were able to calculate the ppm of the DBM in the receptor solution using its area count output.

The experiment is not entirely complete however, enough data has been compiled to theorize about the experimental system's effectiveness. Consistent results have been obtained from the experiments with dibromomethane and butyl rubber. It is believed that the experimental system that is described will provide accurate, reproducible data.. To arrive at these conclusions DBM standard curves were analyzed and compared to one another. From the ppm comparisons of the DBM we can determine the flux of the chemical (measured in mg/cm^3) through a membrane. With this one can predict the amount of chemical that diffuses through the skin. This will be helpful in determining dose levels for dermally applied medications and safe exposure levels for potentially hazardous chemicals.

Appendix 1

DBM PPM Compilation

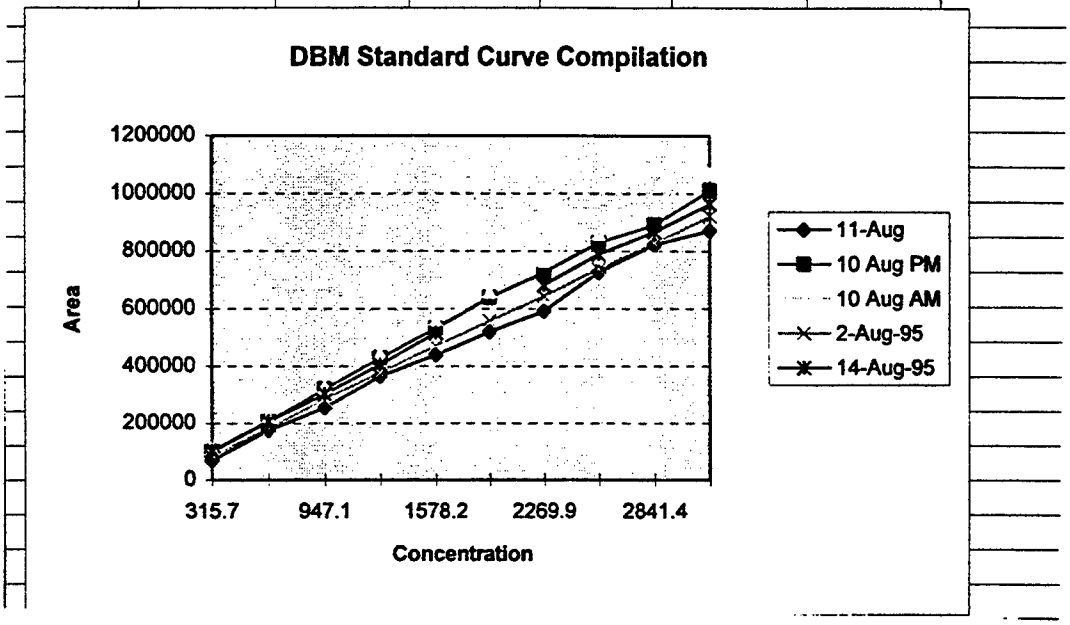
Time	2-Aug-95	11 Aug 95 I	14-Aug-95	16-Aug-95	16 Aug 95 PM	17 Aug 95 AM
15	0	0	0	0	0	0
30	0	0	0	0	0	0
45	0	95	30	0	0	0
60	0	332	277	60	22	44
75	22	716	594	296	364	307
90	228	1107	1101	683	698	694
105	491	1544	1618	1147	1220	1014
120	804	1884	1953	1369	1544	1435
135	979	2246	2307	2031	1906	1841
150	1436	2724	3042	2333	2519	2227
165	1678	3410	3379	2742	2963	2531
180	2091	3538	3404	3336	3535	3155



Appendix 2

DBM Standard Curve Compilation

Conc.	11-Aug	10 Aug P	10 Aug A	2-Aug-95	14-Aug-95
315.7	70562	101210	110590	85923	103220
631.4	175950	207430	223410	183700	208690
947.1	255690	320780	329970	285590	303730
1262.8	364720	428470	444340	378600	405790
1578.2	439730	532650	562050	471220	516570
1894.2	520390	639850	659760	557578	
2269.9	592340	725530	768960	643590	682570
2525.7	726780	829220	862650	739190	789060
2841.4	823280	892550	965350	829450	867860
3157.1	871750	1011300	1069400	920650	963470



Brian Spears report not available at time of publication.

IMPACT TEST RESEARCH ON JPATS MANIKIN STUDY AND BIODYNAMIC DATABASE

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Final Report for:
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August 1995

IMPACT TEST RESEARCH ON JPATS MANIKIN STUDY AND BIODYNAMIC DATABASE

Laura L. Stafford
Centerville High School

Abstract

The JPATS manikin study tested several manikins on the Vertical Deceleration Tower applying downward impact decelerations and also on the Horizontal Impulse Accelerator applying forward and lateral impact accelerations. The tests performed on the manikins were compared to human test results and analyzed to determine if the manikins simulated human response. These manikins are needed to evaluate dynamic response to impact stresses that are not safe for human volunteers. The tests incorporate several different levels of impact on each manikin, and the response of the manikins to the impacts (in the x, y, and z axes) are measured and analyzed to determine if the manikins can be used to investigate human response to the impacts of escape systems. Additionally, references used in impact related studies and reports are put into the Biodynamic Database so that researchers can easily obtain them.

IMPACT TEST RESEARCH ON JPATS MANIKIN STUDY AND BIODYNAMIC DATABASE

Laura L. Stafford

Introduction

I worked as an apprentice for seven weeks this summer in the Armstrong Laboratory at Wright-Patterson Air Force Base, Dayton, Ohio. This particular laboratory specializes in ejection seat impact and protection. I assisted in analyzing impact data resulting the particular Joint Primary Aircraft Training System (JPATS) study done earlier this spring. This study tested manikins and analyzed their response in an emergency ejection situation. I compiled the analyzed data and made tables and charts displaying the results. I was also able to work with the Biodynamic Database when I imported references from an older obsolete format to the format of the new database. I learned how to use unfamiliar sophisticated computer software which helped improve my computer skills, such as mobility in Windows as well as mobility in DOS.

Methodology

Data of the accelerations and forces taken during impact were processed and recorded for all manikins. I took the data of peak impact values and subtracted the preimpact values to obtain the absolute values of each number. Next, I took these numbers and translated them into a table so I could more easily analyze them with statistics software. I then found the means and standard deviations of each of the manikin's responses (head, chest, etc.) at each acceleration level with the statistics software (see appendix A). Then I used the software to conduct Mann-Whitney U tests on several channels to determine how comparable the manikins were to humans, as well as to other manikins (see appendix A). Repeatability tests were conducted on several channels to evaluate how reliable the data was, and to see if the numbers were generally consistent (see appendix A). After analyzing the data I created line graphs of certain channels that included all the manikins to see if they correlated as they should (see appendix B). The last thing I did was produce a regression line of the human data, and then I plotted the means of the manikin data on the same graph to determine how they related to each other (see appendix B).

During the tour I was able to work with the Biodynamic Database, populating it with new impact related reports. The first few references were in a file on the computer. However, the form did not correspond to the current database format. Therefore, I reformatted the references so they could be imported into the database. I also scanned in several references. However they still required a new format. After some experimenting I found it was less time consuming to manually type the references directly into the database. In addition to learning about databases, I became familiar with how technical reports are structured, as well as how lab reports are constructed.

I learned many new things about computers during my tour, and when I was asked to upgrade some computer software, I knew I was about to learn more. I was asked to install an upgrade for Pathworks networking software on several computers. I was given an instruction sheet to guide me through the process, and was helped on the first few installations. Going through the installation process I learned how software is set up, and how specific steps are required to enable the software to work properly.

Conclusion

During the many weeks I have spent in the Armstrong Lab I have gained many new experiences, some of which have influenced my career goals. Working with the JPATS study I saw the kind of work engineers do, and saw how they improve aerospace technology. I am used to mathematics and physics with no applications, and now I have witnessed them being used to solve real world problems. I have always felt intimidated by computers, but being exposed to them day after day, as well as working with different and new software, has made me more comfortable using them, and provided me with more self confidence.

APPENDIX

A

Table1. Summary of Z-Axis Mean Peak Magnitudes at 10G (Cell A)

Channel	JPATS-S	JPATS-L	ADAM-L	Human-F	Human-M
Carriage Z Accel (G)	10.02 ± .07	10.00 ± 0.07	9.86 ± 0.07	9.97 ± 0.07	9.07 ± 2.78
Ext Chest Z Accel (G)	15.20 ± 1.76	16.03 ± .78	14.64 ± 1.10	13.29 ± 1.16	14.95 ± 1.89
Seat Z Force (LBS)	1390 ± 84.78	2940 ± 60.50	2764 ± 72.46	1465 ± 131.3	1946 ± 203.6
Head Z Accel (G)	12.31 ± 0.46	12.82 ± 0.42	13.82 ± 0.57	12.07 ± 1.17	13.81 ± 1.65
Int Chest Z Accel (G)	12.43 ± 0.40	13.23 ± 0.07	14.16 ± 0.37	–	–
Pelvis Z Accel (G)	11.92 ± 0.24	11.58 ± 0.17	13.56 ± 0.84	–	–
Neck Z Force (LBS)	113.0 ± 5.76	150.2 ± 5.19	148.9 ± 5.91	–	200*
Lumbar Z Force (LBS)	725.1 ± 40.41	1115 ± 23.94	1099 ± 25.81	–	–
Lumbar MY Torque (IN-LBS)	418.4- ± 60.83	1102- ± 148.4	669.6- ± 60.80	–	–
Neck MY Torque (IN-LBS)	31.84- ± 7.95	85.13- ± 4.33	109.6- ± 10.03	–	300*

*Estimated

Table 6. JPATS-S Mean Peak Magnitudes in Z-Axis (Cells B-E)

Channel	10G Cell B	15G Cell C	20G Cell D	24G Cell E
Carriage Z Accel (G)	10.10 ± 0.06	15.04 ± 0.08	20.11 ± 0.04	24.18 ± 0.21
Ext Chest Z Accel (G)	14.40 ± 1.01	37.66 ± 4.70	47.71 ± 3.15	54.64 ± 5.36
Seat Z Force (LBS)	1347 ± 14.19	2312 ± 30.76	3309 ± 52.92	4152 ± 33.40
Head Z Accel (G)	11.68 ± 0.13	22.63 ± 0.68	30.84 ± 0.28	37.47 ± 1.08
Int Chest Z Accel (G)	12.15 ± 0.25	22.69 ± 0.90	31.02 ± 0.28	38.54 ± 1.30
Pelvis Z Accel (G)	11.91 ± 0.26	21.02 ± 1.02	28.18 ± 1.16	33.91 ± 1.79
Neck Z Force (LBS)	116 ± 3.33	216.5 ± 14.03	306.4 ± 4.58	363.2 ± 13.95
Lumbar Z Force (LBS)	711.5 ± 13.31	1281 ± 40.26	1775 ± 26.56	2125 ± 32.32
Lumbar MY Torque (IN-LBS)	545.0- ± 66.69	689.5- ±135.2	1027- ± 134.1	1161- ± 44.8

Table 2. Mann-Whitney U Tests of Human vs. Manikin Peak Magnitudes at 10G (Cell A)

Channel	JPATS-L	Human-M	%Difference	JPATS-S	Human-F	%Difference
Head Z Accel (G)	12.82	13.82	-7.2%	12.31	12.07	NSD
Ext Chest Z Accel (G)	16.03	14.95	+ 7.2%	15.20	13.29	+ 14.4%
Seat Z Force (LBS)	2940	1946	+ 51.1%	1390	1465	NSD
Neck Z Force (LBS)	150.2	200	-33.2%	–	–	–
Neck MY Torque (IN-LBS)	85.13	300	-71.6%	–	–	–

Table 29. Mann-Whitney U Tests of JPATS-L vs. ADAM-L Peak Magnitudes at 7G (Cell F)

Channel	JPATS-L	ADAM-L	% Difference
Head Y Accel (G)	16.54	19.82	- 16.5%
Int Chest Y Accel (G)	17.42	18.52	- 5.94%
Pelvis Y Accel (G)	15.08	14.72	NSD
Neck Y Force (G)	182.3	190.0	- 4.05%
Neck MX Torque (IN-LBS)	528.8	516.8	NSD
Lumbar MX Torque (IN-LBS)	2087	1056	+49.9%

Table 10. Repeatability of Manikin Dynamic Response (Cell A)

Channel	JPATS-S	JPATS-L	ADAM-L
Carriage Z Accel (G)	± 1.4%	± 1.4%	± 1.6%
Ext Chest Z Accel (G)	± 23.2%	± 9.7%	± 8.1%
Seat Z Force (LBS)	± 12.2%	± 4.1%	± 5.2%
Head Z Accel (G)	± 7.5%	± 6.6%	± 4.7%
Int Chest Z Accel (G)	± 6.45%	± 1.1%	± 10.2%
Pelvis Z Accel (G)	± 4.0%	± 2.9%	± 8.4%
Neck Z Force (LBS)	± 10.2%	± 6.9%	± 6.3%
Lumbar Z Force (LBS)	± 11.1%	± 4.3%	± 4.6%
Lumbar MY Torque (IN-LBS)	± 29.1%	± 26.9%	± 16.0%
Neck MY Torque (IN-LBS)	± 49.9%	± 10.2%	± 8.4%

Table 26. Repeatability of Manikin Dynamic Response (Cell L)

Channel	JPATS-L	JPATS-S
Sled X Accel (G)	± 1.8%	± 5.8%
Ext Chest X Accel (G)	± 19.8%	± 3.4%
Head X Accel (G)	± 6.1%	± 13.5%
Int Chest X Accel (G)	± 11.2%	± 5.7%
Pelvis X Accel (G)	± 9.9%	± 10.3%
Neck X Accel (G)	± 6.9%	± 28.7%
Lumbar X Force (LBS)	± 43.2%	± 35.9%
Neck MY Torque (IN-LBS)	± 36.9%	± 9.3%
Lumbar MY Torque (IN-LBS)	23.7%	± 21.4%

APPENDIX
B

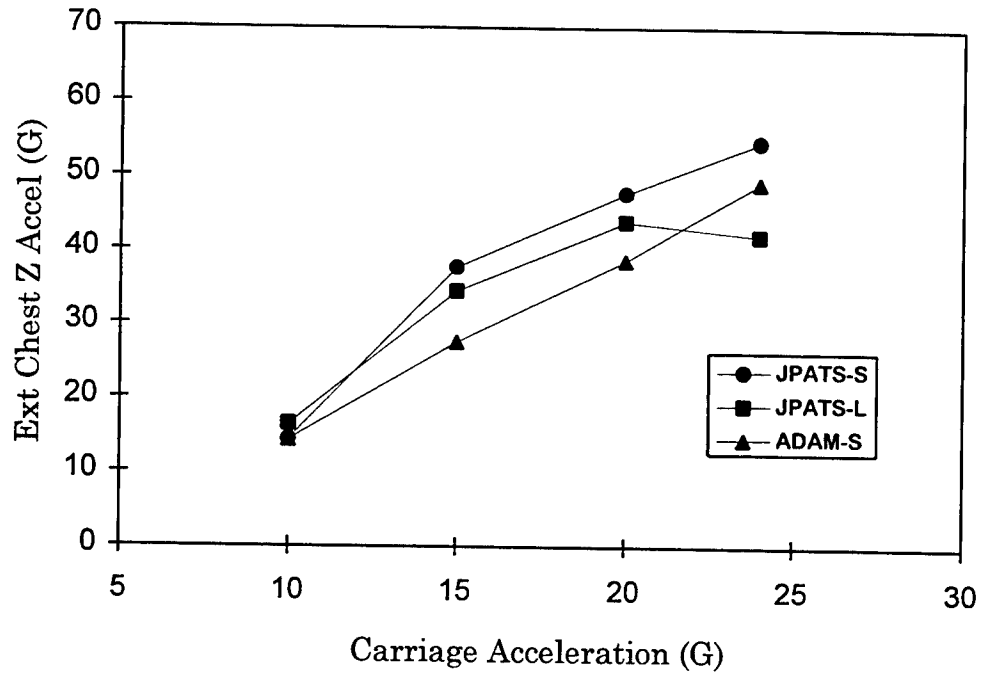

Fig 1. External Chest Z Acceleration vs. Carriage Acceleration

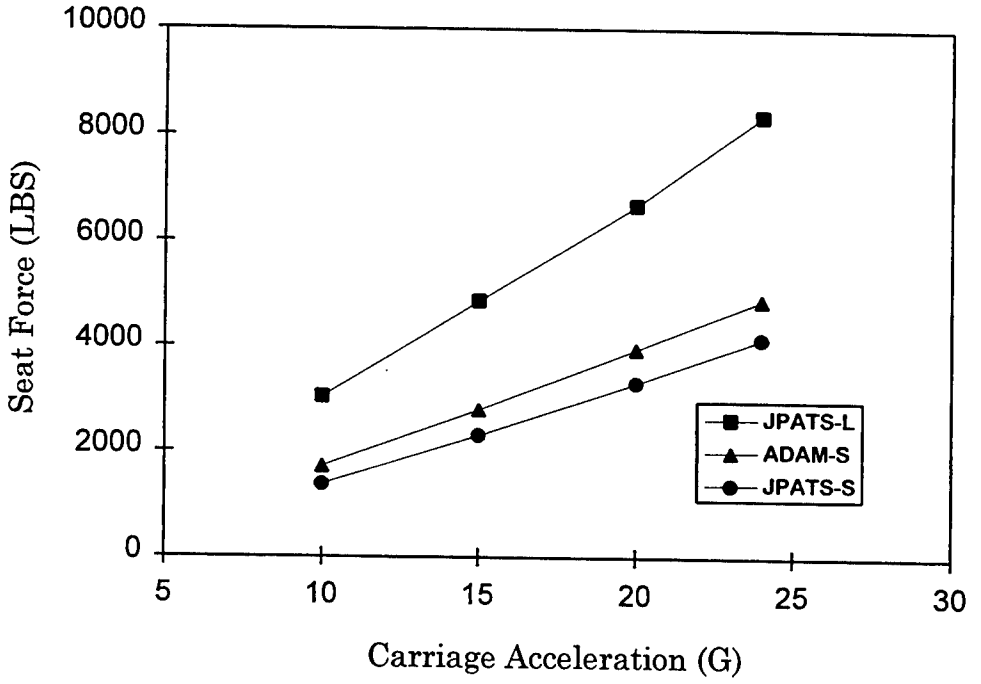

Fig 2. Seat Force vs. Carriage Acceleration

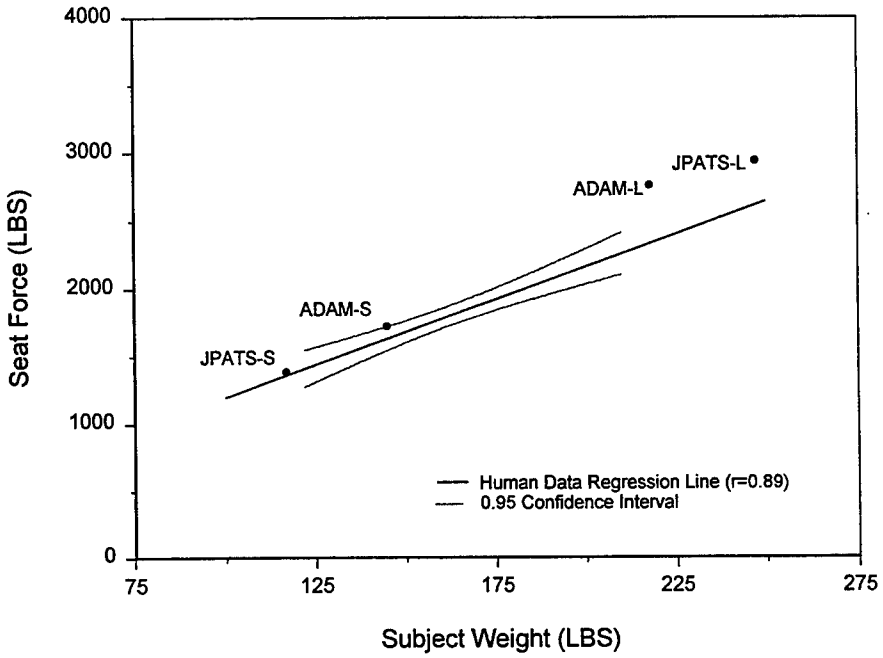

Fig 9. Resultant Seat Force vs. Subject Weight (Cell A)

THE EFFECTS OF HEARING PROTECTION DEVICES ON AUDITORY LOCALIZATION

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Final Report for:
High School Apprenticeship Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
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and

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August 1995

THE EFFECTS OF HEARING PROTECTION DEVICES ON AUDITORY LOCALIZATION

Melanie Strong
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Abstract

This experiment on auditory localization was undertaken in order to discover how hearing protection devices,e.g. earplugs and circumoral earmuffs, affect one's ability to localize. Six subjects were presented pink noise under three randomized conditions: earplugs, earmuffs, and open ear. When compared to the open ear, some impairment was observed while earplugs were worn but not as much as in earmuff conditions. Although earplugs do impair one's ability to localize to some extent, the practical implication is in support of the use of earplugs rather than earmuffs in noisy environments.

THE EFFECTS OF HEARING PROTECTION DEVICES ON AUDITORY LOCALIZATION

Melanie Strong

Background

Auditory localization is essential for the continual monitoring of our surroundings. The term "localization" refers to the judgment and distance of a sound source. This ability is of considerable importance because it determines the direction of objects to seek or avoid, and it indicates the appropriate direction to direct visual attention. As well as being able to judge the direction of a sound source, in some cases we are able to estimate its distance.

Because of the potential risk of danger and accidents, many noisy occupational environments demand alertness with an acute localization ability. At the same time, many occupations require the proper use of hearing protection as a precaution in order to decrease the risk of damage to the auditory system. In these occupational environments in which hearing protection devices are used, workers must know if their safety, protected by their ability to localize, is in jeopardy.

Objective

The objective of this study is to determine the affects of different types of hearing protection devices on one's localization ability.

Equipment

The Auditory Localization Facility (ALF) of the Armstrong Laboratory is contained in a large anechoic chamber with 1.1 m fiberglass wedges protruding from the walls. The dimensions of the chamber (from wedge tip to wedge tip) are approximately 6.7 m x 6.7 m x 6.7 m. The subjects were placed

in the center of the geodesic sphere (diameter of 4.3 m) of 277 speakers (Bose 4.5 in Helical-Voice-Coil, full range drivers). The subjects were seated on an 81 cm x 30 cm bench which is attached to an 87 cm x 60 cm platform. A chin rest was used in order to prevent head movement. The subject's task on each trial was to position the tip of the Polhemus stylus at a point on the spherical God's eye model. This stylus is connected to a Polhemus Fastrak. The Fastrak is connected to the serial-communications port of an 80486-based personal computer. When the foot-switch is depressed, the software on the computer sends the information to the Fastrak which returns coordinates indicating the position of the stylus.

Methodology

A. Subjects: Three males and three females served as subjects. Their age range is between 18 and 34 years. All subjects have normal hearing (better than 15 dB) at 125 Hz to 8 kHz and have underwent a middle ear and eye exam. All subjects received training with the God's eye localization pointing (GELP) technique. This technique was studied and found to be the most accessable because it allows for rapidly collected responses (Gilkey 1994). During the first part of training the subject's head was not fixed so that he or she could locate the noise source which had the LED lights illuminated. Once the subject became familiar with the GELP technique, his or her head was fixed and the LEDs were no longer used. Data from the training was collected and analyzed. Once the subjects' performances plateaued, they were prepared to initiate the experiment.

B. Stimulus: Pulsed pink noise at 70 dB with a band limit from 100 Hz to 10 kHz was used as the stimulus.

C. Procedure: The subjects underwent three randomized conditions of: 1) open ear, 2) an E.A.R. ear plug with a supervised fit in order to maintain consistent depth for each subject, and 3) a circumoral ear muff. For each of

the conditions there were ten runs. Each run consisted of 246 trials. Each run lasted approximately thirty minutes. In each trial: 1) the pink noise was sounded from one of the speakers, 2) the subject pointed to the perceived location of the noise source on the globe with the stylus, 3) the subject depressed the foot-switch while the stylus was on the globe, and 4) the trial was recorded.

Analysis and Results

The subject's results were analyzed on their accuracy in three different planes of: 1) up-down, 2) left-right, and 3) front-back.

Up-Down

Under normal hearing conditions, errors in this plane were limited. When earplugs were worn the amount of judgment error increased, but not as drastically as when the earmuffs were worn.

Front-Back

Without hearing protection, subjects performed with a fairly small amount of error. The amount of error increased dramatically when earplugs were worn, but the most error occurred when the subjects were wearing earmuffs.This plane appears to be one in which the location of sounds is least distinguishable especially when hearing protection devices were implemented.

Left-Right

Subjects, under normal hearing conditions, responded with very little error. When earplugs as well as earmuffs were worn, the amount of error increased only slightly. This plane appears to be one in which the location of sounds is most distinguishable under any of the conditions.

Conclusion

Although earplugs do impair one's ability to localize to some extent, the practical implication is in support of the use of earplugs rather than

earmuffs in noisy environments.

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THE ASSESSMENT OF LIVE FIRE TESTS FOR AIRCREW SURVIVABILITY

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Final Report for:
High School Apprenticeship Program
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Sponsored by:
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August 1995

THE ASSESSMENT OF LIVE FIRE TESTS FOR AIRCREW SURVIVABILITY

Emily Nicole Thompson
Kettering Fairmont High School

ABSTRACT

A polyurethane foam pilot manikin was placed in a cockpit of a fighter plane. A warhead was detonated at close range for the purpose of simulating the probable effects of the weapon in times of live fire attacks. The manikin was removed and transported to the laboratory. The foam provided a penetrable cushion in which flying warhead fragments are captured. Depending on a fragment's properties -- shape, mass, velocity, and angle of entry -- the level of incapacitation of the pilot can be determined through the implementation of computer science. From this prediction, researchers can determine if the development of more protective armor should be recommended.

The Assessment of Live Fire Simulations
for Crew Survivability

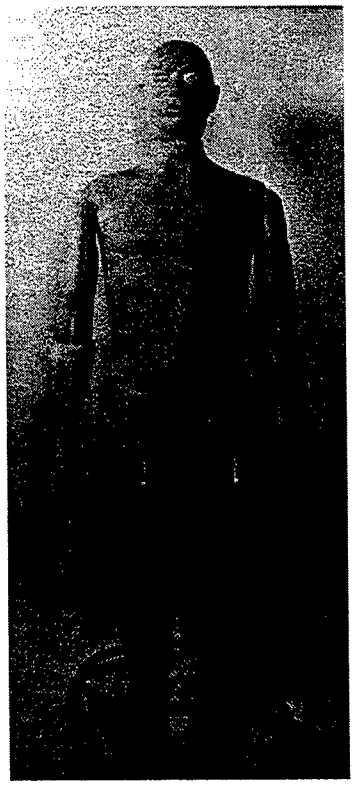
Emily Nicole Thompson

INTRODUCTION

Congress passed a Live Fire Test Law that requires survivability testing and evaluation of all weapons systems before approval for full scale production. This was difficult for many military institutions because of the lack of methodology that existed to fulfill the Congressional requirement. Captain John H. Coleman III and his staff provided a comprehensive plan in 1994. Now it is possible to gather and analyze the needed information systematically so that accurate calculations can be made.

METHODOLOGY

The theory behind the live fire simulation is as follows: by placing a manikin inside of a cockpit, simulating the live fire, locating and analyzing the fragments impelled into the manikin, a reliable prognosis of the crew's injuries is attainable. The assessment of the injuries will help determine if the cockpit is too hostile of an environment for the crew – which is the pilot in this case.



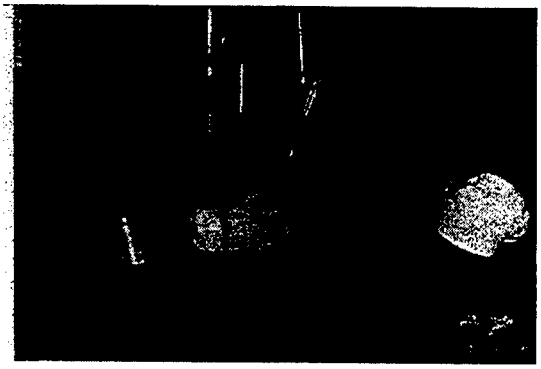
AIRMAN

The key factor in the experiment is to select a material that is able to "capture the fragment intact and retain a sufficient ballistics data set to permit the assessment of the penetrating fragments on the survivability of the crew," (Tsou 5). The AIRMAN – Aerospace Incapacitation Responce Manikin -- was designed to capture the projectiles that may come in contact with the pilot. The foam provides a rigid, consistent material that can be molded into twelve parts of the body and is easily manufactured [see diagram]. The life-sized model is placed in the cockpit, equipped with the proper attire to serve as a human surrogate during the live fire simulation. After the test, the manikin is disassembled and brought to the laboratory.

Track length

Each piece is separately x-rayed for internal fragments. More precise x-rays are taken of the parts containing "good frags" -- fragments seen clearly on the x-ray and that have slight shadow of the fragment's track. A combination of anterior (0 degrees rotation of the part) and lateral (90 degrees rotation) x-rays can help determine the location of the fragment.

The next phase is to determine exactly where the fragments are and calculate their track length. This is measurable through the technology of computer science. The dimensions of each piece of the manikin were pre-programmed into the computer using a three-dimensional digitizer. The program uses these coordinates to distinguish between the different pieces and to orient itself to the specific part being analyzed [see figure]. It is vital that the part be placed in the test fixture exactly in the same direction and angle as it was when it was programmed into the computer originally, otherwise error may occur in the final calculations. Once the part is properly positioned in the zero-degree position, the digitizer is reoriented to that specific part. This is accomplished by clicking on three of the four corners of the workspace, the centers of rotation, the fiducial lines, and the point of penetration (POP) of the fragment. This information is fed into the computer and is represented on the monitor on a Cartesian plane.



After the digitizing is completed, the computer calculates where the fragment entered. To determine the track length, it has to be told where the fragment finally rested. The x-rays give two-dimensional accounts for the fragment. The x-rays are vertically aligned on a light table. A specialized mouse, that has a window to see the table below, can also click on the fiducial lines and the fragment itself. Then the computer calculates the track length and displays the results on the preliminary Cartesian plane. The coordinates are then translated into ComputerMan coordinates. ComputerMan is a wound simulation program designed by the Army to predict the damage caused to a human being having been struck by a projectile.

Mass

Before ComputerMan can be used, the mass, shape factor, and velocity have to be determined. To find the fragment's mass, it must be carefully removed from the manikin. The x-rays aid in physically estimating where the fragment is inside the body part. To obtain the fragment, slice the manikin across the track length it made, about one-half of an inch short of the actual fragment. Then the remaining debris can be gently scraped away and the fragment extracted. Mass and density can be determined through conventional means.

Shape Factor

The shape factor of the fragment determines how easily it goes through the foam. For example a quarter thrown with the smallest edge forward will make a larger track length than one thrown with the flat edge forward. Projectiles take the path with the least resistance, which causes them to turn or make an irregular path. The shape factor represents the probability of its shape having an effect on its motion.

This factor was ignored in previous experiments creating a margin of error. The presented area, Ap, is the area of the face that made the hole of penetration. This also carries weight in terms of the shape factor and how the fragment goes in to the foam.

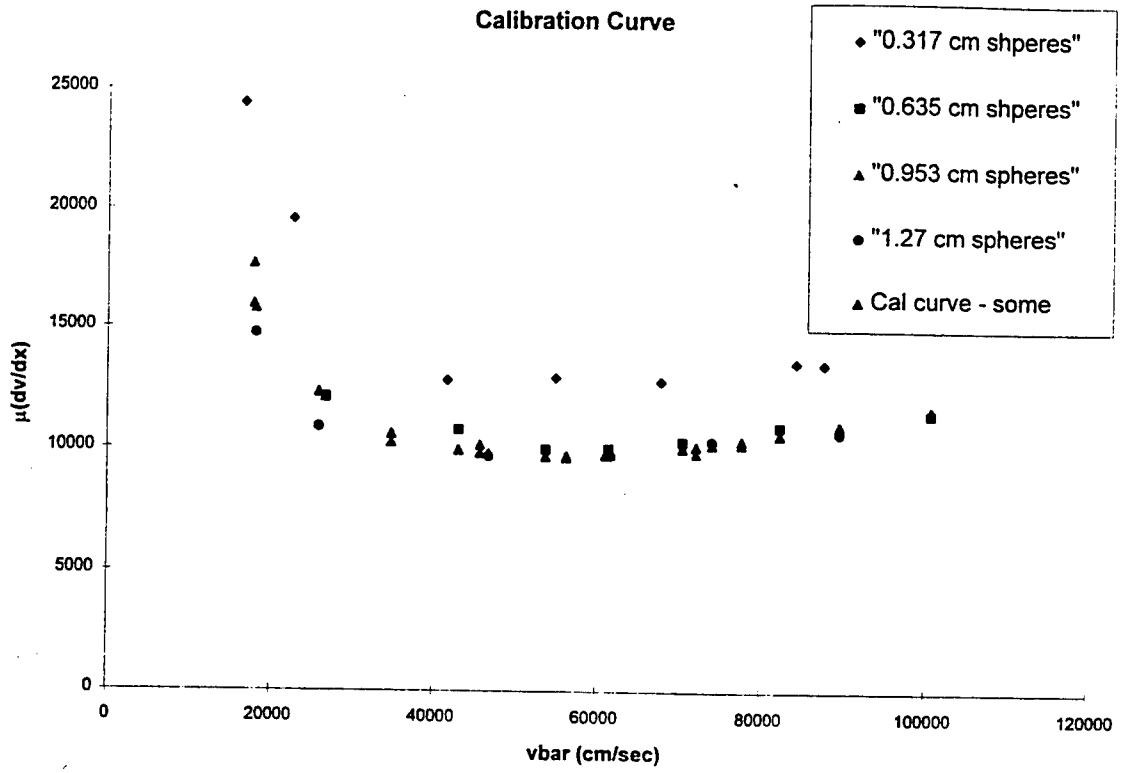
Velocity

Velocity can be calculated from a formula using the penetration track length and fragment's own properties including mass, density, and the shape factor. This formula is derived from the calibration of data from a study involving steel spherical balls. The goal of the study was to "generate a data base of standard projectiles into isotropic capture material from which extrapolations for nonstandard variations can be made," (Tsou 7). Spherical balls of varying sizes, masses, and velocities were fired into the rigid polyurethane foam. Based on their experimental penetration lengths verses their velocities, a formula was derived from a calibration of the curve [see "Penetration vs. Velocity" graph]. This formula was then adapted to calculate the velocity of any radius projectile, given the information needed for the penetration data [see "Calibration Curve" graph]. The adaptation resulted in the calculation of the missing coefficients required for the completion of the formula for the velocities of the warhead fragments.

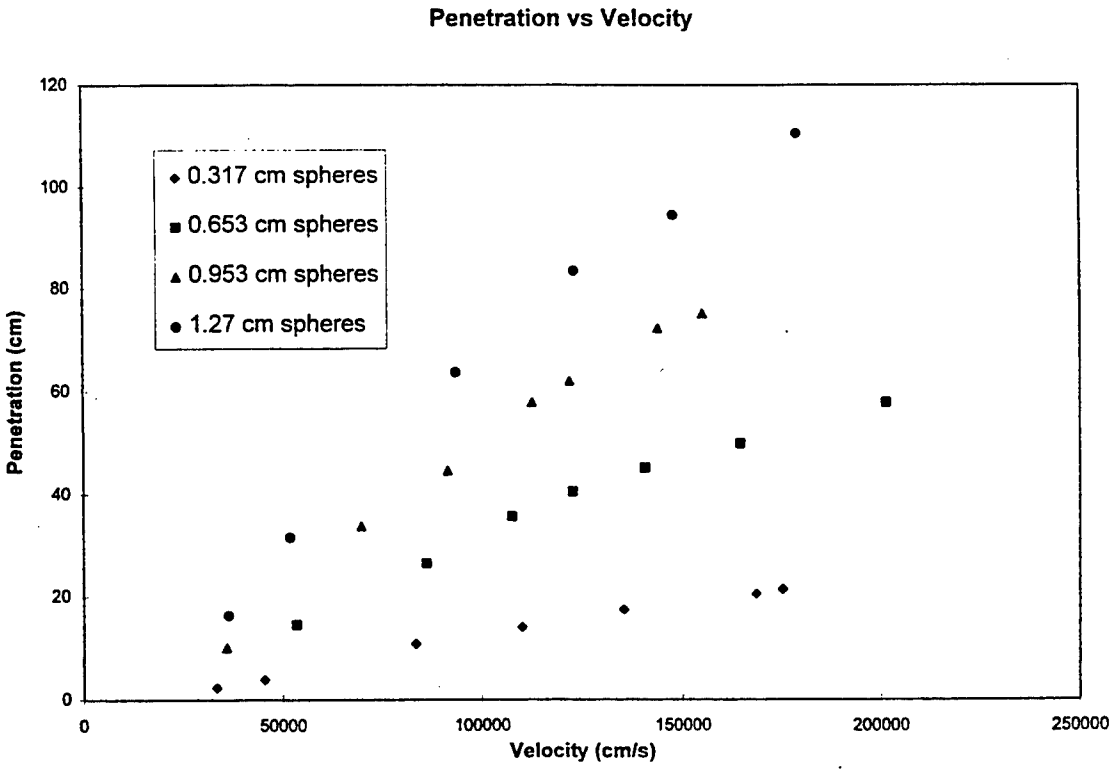
Survivability Assessment

The actual survivability assessment is based mostly upon the Army's ComputerMan program. ComputerMan is a "model designed to predict the biomechanical degradation and threat to life to personnel who sustain penetrating injuries," (Saucier 1). The program assesses the damage caused by the given mass, density, velocity, et cetera of the fragment. A report is provided of the individual's expected injuries and his level of incapacitation. The ComputerMan is a representation of the anatomy of a man divided into 167 horizontal cross-sections stored in the program's memory. The information from ComputerMan can be indirectly interpreted as to whether or not the pilot will be able to operate the aircraft and land it safely. Obviously, the pilot will be able to keep flying if the injuries are as minor as a flesh wound or bruise. If the damage is severe, it may cause the pilot to lose the ability to keep flying. In such a case it would not matter how well the plane was still operating, if there is no pilot, there is no plane.

Cal Curve



Pen vs Vel



RESULTS

During the Live Fire Test the AIRMAN wore fatigues instead of the standard flight suit in our case. When the warhead exploded, the hot fragments may have caused the uniform to ignite -- this may not have happened if the flame retardant flight suit was used. In any event, the manikin was badly burned from the lower torso to the top of its head. Many of the points of penetration were difficult to find -- either too much debris blocked the hole, or the hole itself melted closed because of the fire. Consequently, we were able to pinpoint and focus on four "good frags": two found in the left upper leg, labeled LUL # 1 and # 2; one found in the lower torso, labeled TOR # 1; and the last one found protruding from the hip of the torso -- having traveled through the left upper leg, labeled TOR # 2 (hip) [see pictures and charts].

Fragment Name	Track length	Weight	X	Y	Z
LUL #1	2.79886"	2.204g	-0.375	-0.975	0.586
LUL #2	2.80575"	0.652g	-0.086	-0.618	-0.929
TOR #1	2.92369"	2.894g	-0.783	-2.478	-3.233
TOR #2 (HIP)	3.61182"	2.000g	-3.017	-5.662	-0.612

VELOCITY:

Fragment Number	Weight (gm)	Ap (cm)	Shape	mu	Penetrate (cm)	Velocity (m/sec)
LUL #1	2.204	0.729676	0.912256	3.020519	7.109104	360.0484
LUL #2	0.652	0.52996	1.492357	1.230281	7.126605	615.0798
TOR #1	2.894			1.436839	7.426173	571.2817
TOR #2	2			3.61182	9.174023	715.6777

The formula for velocity yields: $y = av + b + c/v$, where y is the penetration and v is the average velocity. We found the coefficients to be a= .08819; b= -288; and c= 252,000,000. Since this project is still in process, there is inconclusive data about the torso wounds. However, taking in to account the severity of the penetration, the velocities were probably high and would have caused crippling damage to the lower back.

CONCLUSION

The ComputerMan program provides a detailed description of the injuries that may develop based on ground troop information. Therefore, an interpretation of the data has to be made to determine whether or not these injuries would effect the pilot's flying abilities or judgment. The output from the first fragment, weighing 2.204 grams = 34.007 grains, quoted that the pilot would have a 98% possibility of survival from the injury. However, by following the path made by the fragment, [on the following pages], the fragment

may have broken the pilot's femur bone. The injury, although may not be life-threatening on the ground, can cause the pilot to have difficulties flying the plane. The second fragment caused nerve and muscle damage that may take away from the pilot's concentration. A combination of the two injuries would also make it very difficult for the pilot to land the plane. Furthermore, other injuries could not be calculated because some fragments were propelled completely through the AIRMAN, making it impossible for us to analyze them.

ARL ComputerMan (C++/Motif Version 1.0)
Fri Aug 25 09:55:50 1995

Single Shot Mode

Mass (grains): 34.0077
Striking Velocity (m/sec): 359.969
Shape Factor (dimensionless): 0.848
Density (grams/cc): 2.8
Effective Diameter (mm): 9.5941

Shotline Origin (mm): 141 108 612
Azimuth (degrees): 284.697
Elevation (degrees): 0.90847

Not wearing body armor

TID	SEC	ROW	COL	DISTANCE	DIA	VOLUME	VELOCITY
1	85	29	29	2.5000	9.6	0.0	359.97
1	85	29	29	5.0000	14.	0.018	345.74
136	85	29	30	7.5000	14.	0.0	331.45
136	85	29	30	10.000	8.3	0.036	325.78
136	85	29	31	12.500	8.2	0.050	320.20
136	85	30	31	15.000	8.0	0.063	314.69
136	85	30	32	17.500	7.9	0.076	309.27
136	85	30	32	20.000	7.8	0.088	303.92
136	85	30	33	22.500	7.6	0.10	298.65
136	85	30	33	25.000	7.5	0.11	293.45
136	85	30	34	27.500	7.4	0.12	288.32
136	85	30	34	30.000	7.3	0.13	283.26
140	85	30	35	32.500	7.1	0.0	278.26
140	85	31	35	35.000	10.	0.010	266.18
139	85	31	36	37.500	10.	0.0	253.86
139	85	31	36	40.000	10.	0.020	241.22
139	85	31	37	42.500	10.	0.040	228.21
139	85	31	37	45.000	9.8	0.060	214.71
140	85	31	38	47.500	9.7	0.031	200.62
140	85	31	38	50.000	9.5	0.049	185.76
136	85	32	39	52.500	9.3	0.14	169.90
136	85	32	39	55.000	6.7	0.15	159.17
136	85	32	40	57.500	4.0	0.16	154.85
136	85	32	40	60.000	3.9	0.16	150.49
136	85	32	41	62.500	3.8	0.17	146.08
136	85	32	41	65.000	3.7	0.17	141.63
136	85	32	42	67.500	3.6	0.17	137.11
136	85	32	42	70.000	3.5	0.18	132.52
136	85	33	42	72.500	3.4	0.18	127.84
136	85	33	43	75.000	3.3	0.18	123.06
136	85	33	43	77.500	3.1	0.18	118.16
136	85	33	44	80.000	3.0	0.18	113.12
136	85	33	44	82.500	2.9	0.19	107.91
136	85	33	45	85.000	2.8	0.19	102.50
136	85	33	45	87.500	2.6	0.19	96.847
136	85	33	46	90.000	2.5	0.19	90.896

2	85	34	46	92.500	2.3	0.0	84.576
2	85	34	47	95.000	6.8	0.0011	77.786
2	85	34	47	97.500	6.5	0.010	70.383
2	85	34	48	100.00	6.2	0.019	62.144
2	85	34	48	102.50	5.8	0.026	52.694
1	85	34	49	105.00	5.4	0.056	41.320
1	85	34	49	107.50	4.8	0.062	0.0000

TID: 1 Skin — Hole Diameter (mm): 13.890
TID: 2 Subcutaneous Tissue — Hole Diameter (mm): 6.8074
TID: 136 Muscle (upper leg) — Hole Diameter (mm): 13.617
TID: 139 Femur (medulla) — Hole Diameter (mm): 10.202
TID: 140 Femur (cortex) — Hole Diameter (mm): 10.313

Using the rule F + F = T in combining limb states:

Post-Wounding Time	Biomechanical State (Limb Dysfunction) LArm	RArm	LLeg	RLeg	Degradation in Performance (%) A	D	R	S
30 sec	0	0	0	0	0	0	0	0
5 min	0	0	0	0	0	0	0	0
30 min	0	0	0	0	0	0	0	0
12 hrs	0	0	0	0	0	0	0	0
24 hrs	0	0	0	0	0	0	0	0
5 days	0	0	0	0	0	0	0	0

Survival Probability (using ISS) = 0.98861
Survival Probability (using AP) = 0.98149
Summary of Thoracic Injuries:

AIS Code	AIS Body Region	AIS Severity
10503.2	External	Moderate
10303.2	External	Moderate
91201.2	Lower Extremity	Moderate
92601.3	Lower Extremity	Serious

Single Shot Completed
CPU seconds = 0.88000

ARL ComputerMan (C++/Motif Version 1.0)
Fri Aug 25 10:30:29 1995

Single Shot Mode

Mass (grains): 10.060
Striking Velocity (m/sec): 615.09
Shape Factor (dimensionless): 1.3870
Density (grams/cc): 2.8000
Effective Diameter (mm): 8.1757

Shotline Origin (mm): 136.00 78.000 616.00
Azimuth (degrees): 288.15
Elevation (degrees): 7.9807

Not wearing body armor

TID	SEC	ROW	COL	DISTANCE	DIA	VOLUME	VELOCITY
1	85	35	29	2.5000	8.2	0.0	615.09
1	85	35	29	5.0000	15.	0.013	575.55
2	85	36	30	7.5000	15.	0.0	537.29
2	85	36	30	10.000	14.	0.044	514.45
136	85	36	31	12.500	14.	0.0	492.69
136	85	36	31	15.000	10.	0.039	471.93
136	85	36	32	17.500	10.	0.061	452.12
136	85	36	32	20.000	9.6	0.080	433.20
136	85	37	33	22.500	9.2	0.099	415.12
136	85	37	33	25.000	8.8	0.12	397.83
136	85	37	34	27.500	8.5	0.13	381.27
136	85	37	34	30.000	8.1	0.14	365.40
136	85	37	35	32.500	7.8	0.16	350.17
136	85	37	35	35.000	7.5	0.17	335.54
136	85	37	35	37.500	7.2	0.18	321.47
137	85	38	36	40.000	6.9	0.0	307.91
137	85	38	36	42.500	7.6	0.0093	294.83
136	85	38	37	45.000	7.5	0.19	282.19
136	85	38	37	47.500	6.1	0.20	269.95
136	85	38	38	50.000	5.8	0.21	258.08
136	85	38	38	52.500	5.5	0.22	246.53
136	85	39	39	55.000	5.3	0.22	235.27
136	85	39	39	57.500	5.1	0.23	224.26
136	85	39	40	60.000	4.8	0.23	213.47
136	85	39	40	62.500	4.6	0.24	202.84
136	85	39	41	65.000	4.4	0.24	192.33
136	85	39	41	67.500	4.2	0.24	181.90
136	85	39	42	70.000	3.9	0.25	171.49
136	85	40	42	72.500	3.7	0.25	161.03
136	85	40	43	75.000	3.5	0.25	150.44
136	85	40	43	77.500	3.3	0.26	139.63
136	85	40	43	80.000	3.0	0.26	128.47
136	85	40	44	82.500	2.8	0.26	116.77
136	85	40	44	85.000	2.5	0.26	104.29
136	85	41	45	87.500	2.3	0.26	90.617
136	85	41	45	90.000	2.0	0.26	75.057
2	85	41	46	92.500	1.6	0.084	56.183
2	85	41	46	95.000	4.7	0.085	30.212
2	85	41	47	97.500	3.5	0.089	0.0000

TID: 1 Skin Hole Diameter (mm): 15.410
TID: 2 Subcutaneous Tissue Hole Diameter (mm): 14.914
TID: 136 Muscle (upper leg) Hole Diameter (mm): 14.112
TID: 137 Nerve (sciatic) Hole Diameter (mm): 7.6150

Using the rule F + F = T in combining limb states:

Post-Wounding Time	Biomechanical State (Limb Dysfunction) LArm	RArm	LLeg	RLeg	Degradation in Performance (%) A	D	R	S
30 sec	0	0	2	0	100	50	100	100
5 min	0	0	2	0	100	50	100	100
30 min	0	0	2	0	100	50	100	100

12 hrs	0	0	2	0	100	50	100	100
24 hrs	0	0	2	0	100	50	100	100
5 days	0	0	2	0	100	50	100	100

Survival Probability (using ISS) = 0.98861
Survival Probability (using AP) = 0.98149
Summary of Thoracic Injuries:

AIS Code	AIS Body Region	AIS Severity
10503.2	External	Moderate
10303.2	External	Moderate
91201.2	Lower Extremity	Moderate
90801.3	Lower Extremity	Serious

Single Shot Completed
CPU seconds = 0.82000

WORKS CONSULTED

Coleman, John H., Capt., USAF, BSC. "A Continuity Report for the Aircrew Survivability Assessment Program."

Eveland, Ed and Capt. Becky Schultz (mentor), USAF, AL/CFBV. Vulnerability Branch.

Saucier, Richard and Howard M. Kash, III. "ComputerMan Model Description." ARL-TR-500, August 1994.

Tsou, Peter. "Fragment Ballistics Determination: Interpretation Aid for AIRMAN." JPL D-8278, March 1991.

Associate did not participate in program.

Matthew Villalpando report not available at time of publication.

The Effects of 3 Anti-Emetic Compounds on Sleep Duration and Quality As Measured by Actigraph and Activity Logs

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August 1995

The Effects of 3 Anti-Emetic Compounds on Sleep Duration and Quality As Measured by Actigraph and Activity Logs

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Abstract

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US Air Force personnel must be prepared for many contingencies to ensure the mission succeeds. For example, crews may suffer exposure to low level radiation in future conflicts resulting in severe nausea and producing catastrophic effects on their ability to accomplish the mission. Two novel compounds under consideration as nausea prophylactic agents by NATO, Kytril and Zofran, were tested and found to have no effects on cognitive ability. This study evaluated the effects of the two agents on fatigue and oral temperature as well as on the quality and duration of post session sleep.

The 20 male and 4 female volunteers were selected from military personnel at Brooks AFB. Subjects received actigraphs and activity logs the day before the first session. They were required to wear the actigraphs and fill out the logs for the 9 days to follow. There were four session days; one each for Kytril, Zofran (the test drugs), Compazine (the positive control) and placebo. Order effects were controlled for using a latin square design which mixed up the order in which subjects received the drugs. The session days were separated by a day off to allow for drug washout and sleep recovery before the next session day began. During a session day, subjects were required to go to work as normal and to arrive at the human performance testing habitat by 1630. Hourly cognitive tests then ensued until 0200 at which times the subjects were released.

No differences were found for session days in the amount of pre-session sleep nor post session sleep. During a session, no differences were found for oral temperature nor subjective fatigue scores. These data further support the use of Kytril or Zofran as prophylactic agents to radiation exposure. The study also allowed a comparison of actigraph and log data. The actigraph may offer the most important advantage in objectively recording sleep/wake data whereas log entries are subjective and prone to human error. However, log data can include other data not available on the actigraph like oral temperature and subjective fatigue scores. However, both techniques ultimately provide data that compliment each other and, if possible, both should be used in operational research.

The Effects of 3 Anti-Emetic Compounds on Sleep Duration and Quality As Measured by Actigraph and Activity Logs

Jonathan S.Vinarskai

Introduction

The Sustained Operations Branch of Armstrong Laboratory (AL/CFTO) is tasked with assessing cognitive and physiological impairment in situations faced by US Air Force Personnel. This may involve research into the effects of unusual duty hours during multiple, long duration missions (French, et al, 1993; Neville, et al, 1994) as well as evaluating the effects of novel pharmacological interventions for fatigue (French et al, 1990; Eddy et al; 1992). For this project, AL/CFTO was asked by the Defense Nuclear Agency (DNA), at the request of the North Atlantic Treaty Organization (NATO) countries, to determine the cognitive effects of drugs that might be used to protect crews from the debilitating effects of nausea caused by exposure to low levels of nuclear radiation. The study was necessary to prepare for the contingency that crews might be exposed to radiation in future conflicts and would need all their cognitive skills to return safely. For examples, fuel might be available only at a base that suffered a low level nuclear strike or the only route to return home might require a flight path close enough to a radiation contaminated area to warrant concern about impaired cognitive skills.

The DNA is interested in two compounds that have shown great promise as treatment for nausea experienced by cancer patients undergoing radiation treatment. The drugs are also taken prophylactically to prevent emesis by patients taking anti-cancer medications, which, like radiation therapy, can also cause severe and painful nausea. The generic names for the drugs are ondansetron (trade name Zofran; manufactured by Glaxo Co.) and granisetron (trade name Kytril; manufactured by Smith, Kline and Beecham Co.) and are both approved by the US Food and Drug Administration to prevent or reduce severe emesis.

In spite of the fact that these drugs are given to thousands of cancer patients, there were no data found to indicate if they had any effects on cognitive ability. The AL/CFTO study provided controlled scientific information that the compounds are no different from placebo in producing subjective and cognitive effects. The AL/CFTO study also demonstrated that fatigue induced by sleep deprivation during the circadian performance nadir did not exacerbate the effects of the drugs. The cognitive tests would likely have demonstrated an effect if one was there since a positive control drug was used. A positive control condition is a similar condition (in this case a drug) to the test conditions but one that is expected to produce an effect. This compound,

prochlorperazine (trade name Compazine; manufactured by Smith, Kline and Beechum Co.), is also used to treat severe emesis but is also a major tranquilizer. Prochlorperazine was found to have cognitive effects although the dose used was so low that neither the subjects nor the investigators knew which compound it was.

The remaining analysis for the anti-emetic study is the focus of this report and concerned an evaluation of the activity logs and actigraph data, which are both metrics to determine if the compounds affected sleep duration and quality.

A secondary purpose of the report is to compare actigraph data and log data for use in studies of this kind. Both measure sleep duration and quality and may be redundant. It is important to AL/CFTO to know which technique to use and what are the distinguishing characteristics of each. A number of studies have been conducted in normal subjects that compare self reports with actigraph data. For example, actigraphs were found to be better than self-report or physiological measures (heart rate and O2 uptake) because of their utility and accuracy (Patterson, et al., 1993). These authors performed reliability testing on the actigraph comparing physical activity (walking, running stair climbing, knee bends) with sedentary activity (reading, typing, video games, mental arithmetic task). Actigraph accurately differentiated within activity as well as between activities. Counts correlated with O2 uptake and heart rate during both kinds of activities. In another study, healthy people wore actigraphs for 5 days and the peak activity time was found to occur between 1330 and 1605 (Brown et al., 1990). Troughs of activity correlated well with their log sleep records. These authors concluded that the actigraph is a well-tolerated device to monitor sleep/wake cycles objectively and unobtrusively.

Actigraphs have also been useful in sleep labs for many years as a measure of sleep duration and perhaps as measures of sleep quality. For example, they were found to correlate highly with normal sleep (Brooks et al., 1993). These authors were successful in testing actigraph effectiveness during a sleep restriction treatment study in elderly insomniacs. They also, pointed out that logs were useful in getting the subject's perception of sleep duration which was often quite different from the more objective actigraph record. Another study reviewed techniques for monitoring sleep/wake in field research (Broughton, 1991). They used EKG, core body temperature, subjective reports and actigraphs to study naps and sleepiness in a non-laboratory settings. The current study sought to compare the self-report data collection method (logs) used by the Sustained Operations Branch at Armstrong Laboratory (CFTO) for the purpose of assisting field studies of fatigue in aircrew with actigraphs.

The growing use of actigraphs has led to the development of important improvements in their use and data evaluation techniques.

For example, the leading methods measure sleep quality, the EEG, was correlated with actigraphic measures recently (Cole, et al., 1992). The authors validated methods they developed for EEG scoring on the actigraph. Their sleep/wake prediction algorithm was successful 88% of time in predicting sleep correctly. Sleep percentage and latency measures from actigraph were significantly correlated with polysomnogram records. Finally, automatic, computerized scoring of actigraph sleep/wake data is possible using algorithms available in a software package (GAAP; General Activity Analysis Program) developed for actigraph users. For sleep lab studies, the Cole and Kripke algorithm is best but for field studies the more conservative Walter Reed algorithm is best Both algorithms are available on the GAAP software.

This report then evaluated the sleep quality and duration, prior to and following each anti-emetic drug session. If differences were found pre-session it suggest that fatigue might have influence the interpretation of the results. If post session differences were found that could indicate that one of the compounds might exaggerate crew fatigue. Finally, the advantages of the actigraph compared to the activity log are discussed.

Methods

Volunteers were selected from military personnel at Brooks AFB and the study conducted during December 1994 and January 1995. There were 4 females and 20 males selected. The subjects were run in groups of 8 in the human performance habitat at Brooks AFB. The cognitive tests were administered by computer generated software. Subjects arrived at the habitat at 1630 on test days and were required to take the hourly test battery until 0200 when they were released. They did not report for the next session until after 38 hours for drug washout and recovery sleep. Subjects were required to go to work the day of each drug session. This sequence was repeated until all 4 drug conditions (Kytril, Zofran, Compazine, placebo) were completed. During the session, the activity logs were used to record oral temperature and subjective fatigue. Between sessions, subjects were required to indicate when the slept and the quality of each sleep. Actigraphs recorded sleep automatically.

Both techniques, actigraph and activity logs, were used to assess how long individuals slept (duration) and how well they slept (quality). Two periods were evaluated a.) the sleep period before the drug session and b.) the sleep period after the drug session. This analysis required some decision rules to define a sleep period for both techniques. For the actigraph, a sleep period was defined as more than 10 minutes of scored sleep per hour with activity counts over 15 for the hour. This would prevent a false positive reading for example, if the individual took off the actigraph and left it on a counter, falsely labelling the epoch a

sleep period. For the activity log sleep was simply defined as all log entries that were labelled 'S'. A complete log sheet representing 4 days of data is shown in Appendix 1.

Quality of sleep is harder for the actigraph but more accurate. Quality of sleep for the actigraph is defined as lower counts per hour; that is, if a drug had lower counts during sleep than another then it produced a more restful sleep. For the logs, quality of sleep is defined as a log entry of '+' for better, '=' for same as or '-' for worse than a normal sleep. A value of 2 was given to a '+' score, an '=' got a score of 1 and a '-' a value of 0 for quantifying log sleep quality.

Results

As was previously reported, no differences were found between the test compounds, Zofran and Kytril for cognitive effects compared to placebo. However, Compazine, the positive control, was found to have affected some of the performance metrics. These data suggest that the test compounds can be used by crews as a pre-treatment to avoid the effects of nausea in a nuclear battlefield.

The log data provided hourly information on subjective fatigue using the 7 point scale shown in the appendix and oral temperature during each session. As can be seen from Figure 1, there was a steady increase in fatigue scores during the session but no differences between drugs.

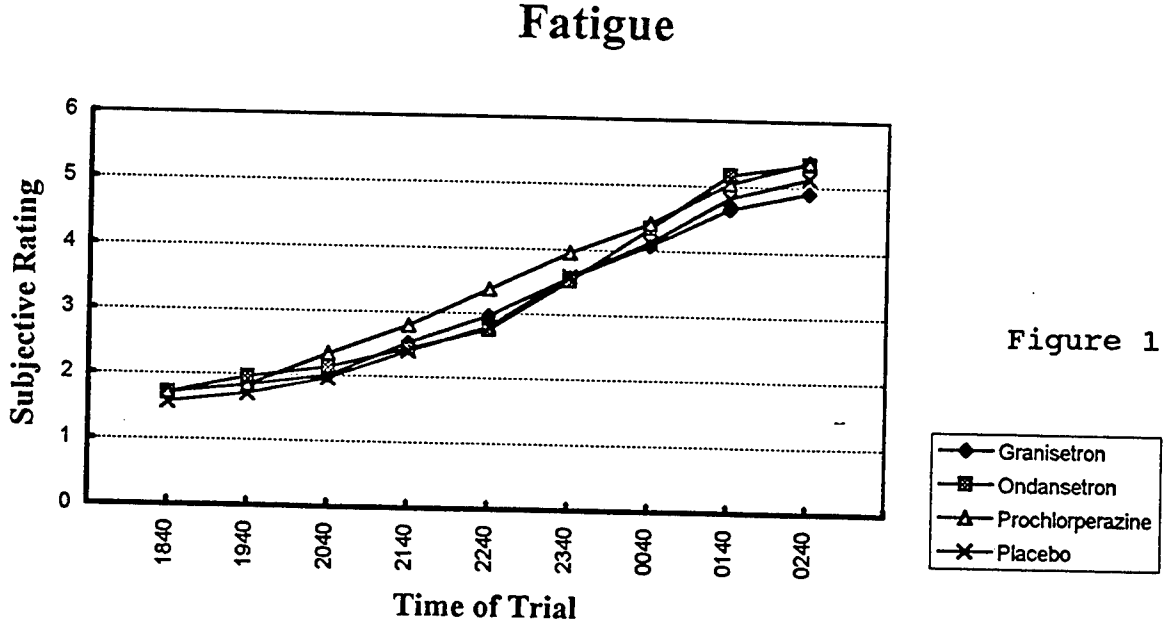

Figure 1

Figure 2 shows that oral temperature data revealed about a one

degree decrease throughout the session but no drug effects. Changes in the temperature and fatigue over time during a session are the result of circadian variation.

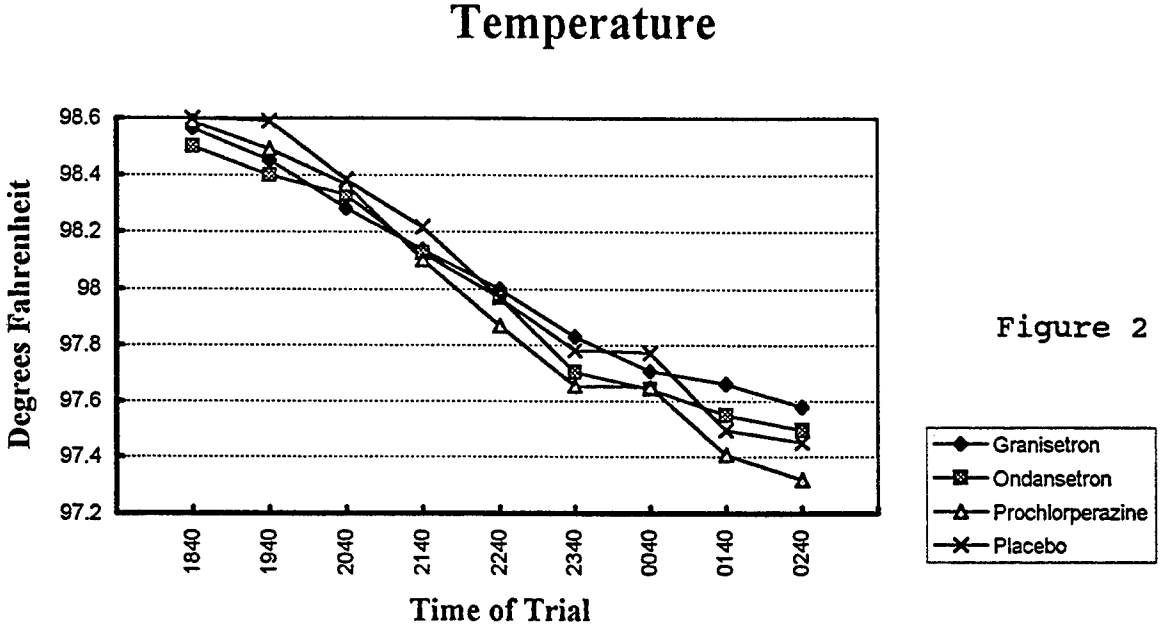

Figure 2

The focus of this investigation was on the quality and duration of the sleep induced prior to and following a drug session. In order to confirm that no differences in sleep prior to a drug session, the pre-session sleep was compared for each drug. The post session sleep was evaluated to determine if a compound produced meaningful effects on sleep.

Figure 3 demonstrates that there is no difference between drugs in terms of pre-session sleep duration as recorded by actigraph ($p < 0.48$) or the activity log ($p < 0.85$).

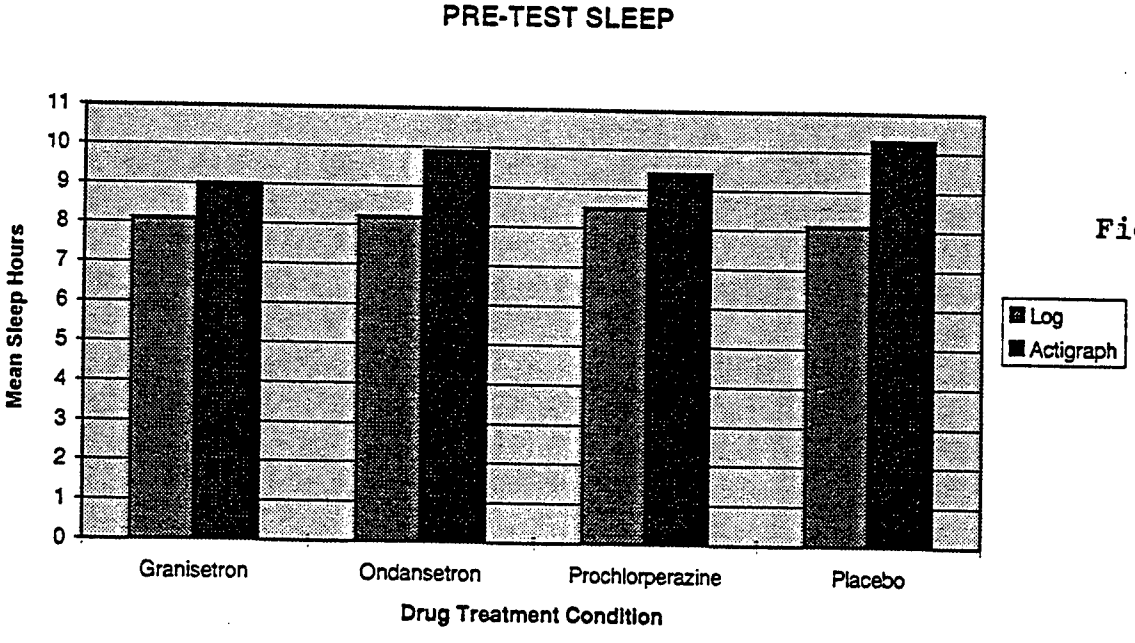

Figure 3

Figure 4 shows the same data re-organized to emphasize the actigraph assessment and the log assessment of sleep duration.

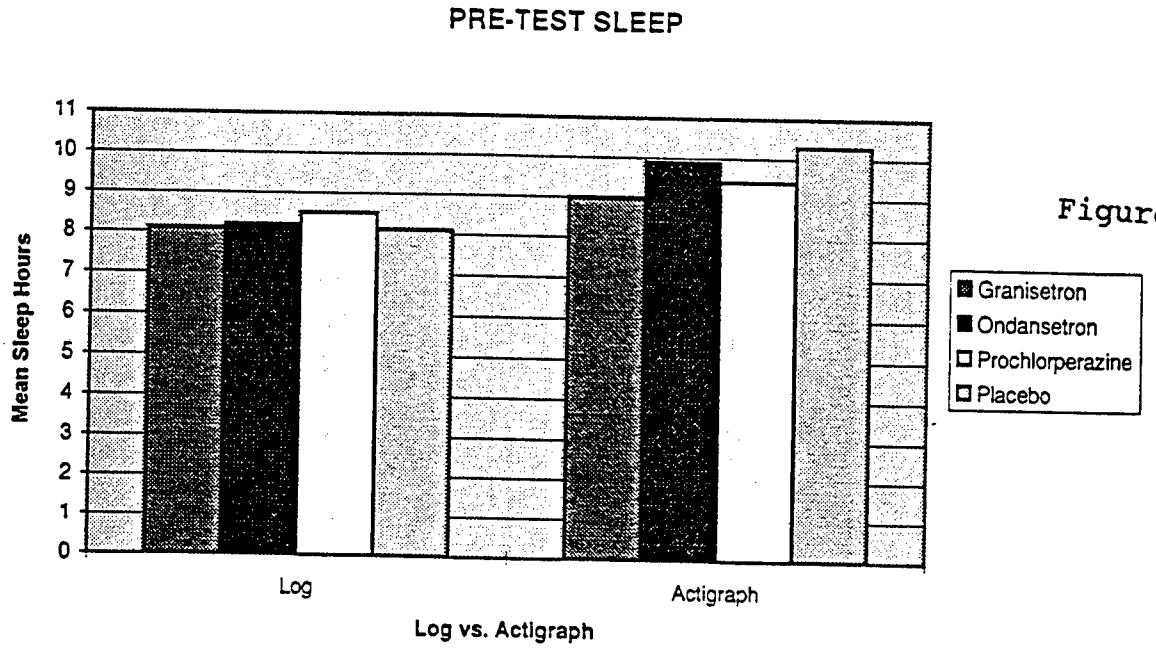

Figure 4

The amount of sleep following a session is not different as shown in Figures 5 and 6 for actigraph ($p < 0.30$) scores nor log scores ($p<0.13$). Figure 5 compares the drugs and Figure 6 re-organizes the data to compare the actigraph assessment and the log assessment. Figures 4 and 6 reveal that the actigraphs tend to score more sleep than the logs.

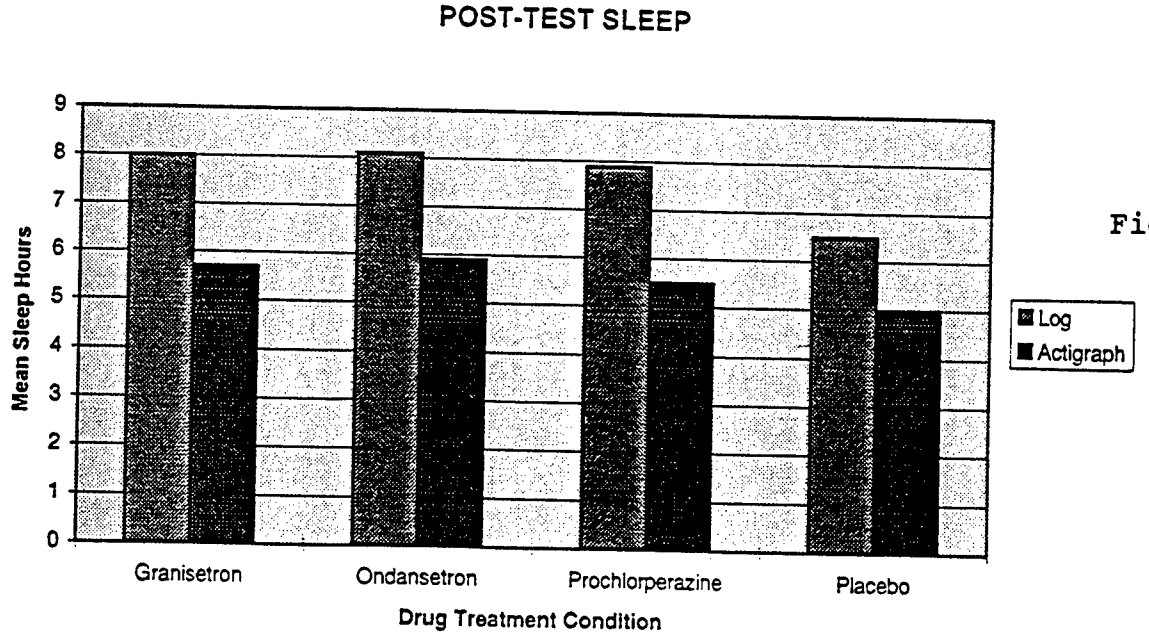

Figure 5

POST-TEST SLEEP

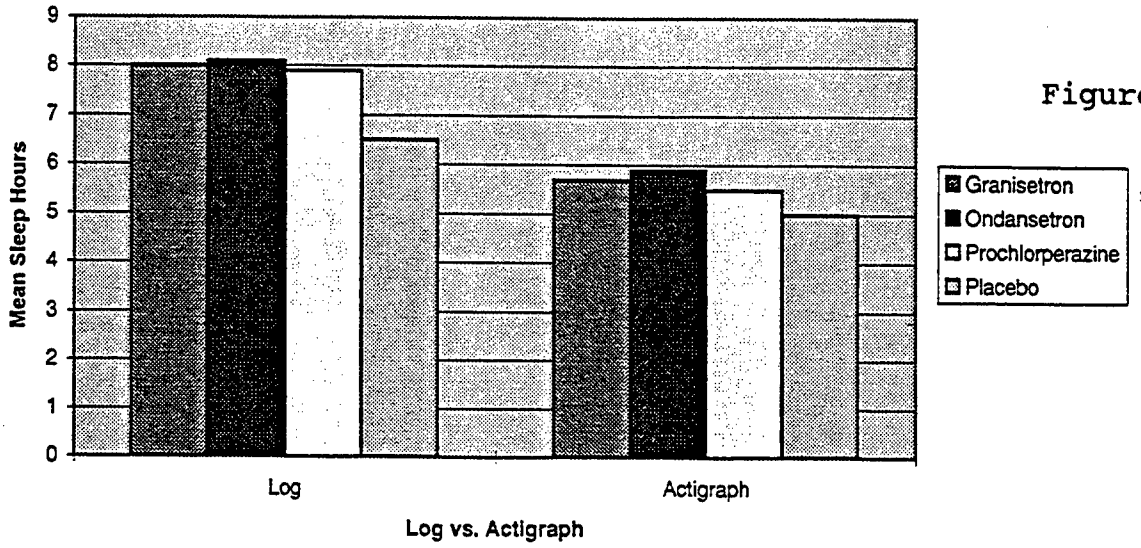

Figure 6

Quality of sleep as measured by the actigraph and logs prior to each session is shown in Figure 7. No differences were found for actigraphs ($p < 0.41$) or logs ($p < 0.06$) quality of sleep.

PRE-TEST SLEEP QUALITY

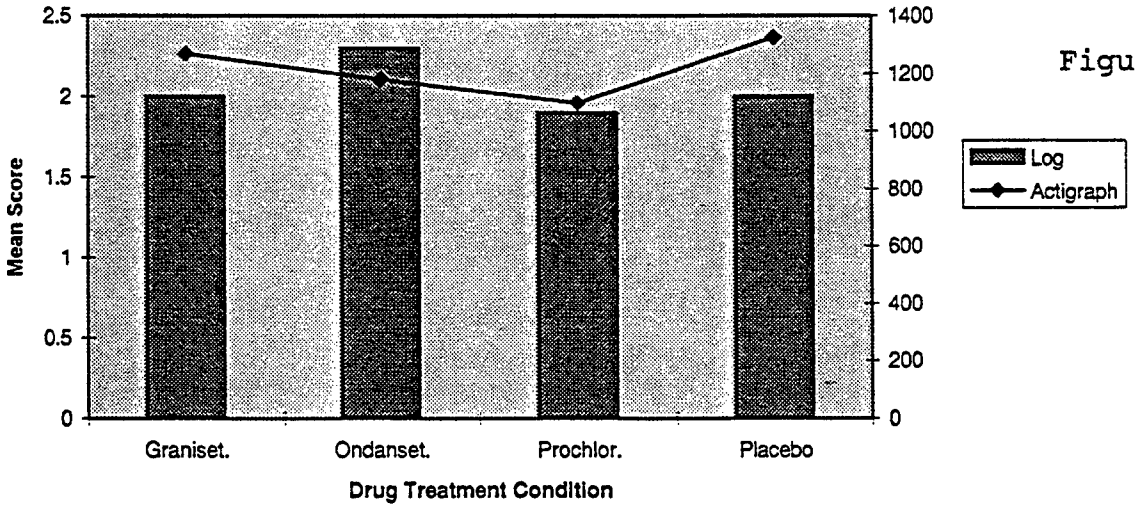

Figure 7

Similarly, Figure 8 reveals that no differences between quality of sleep were found after each session for actigraphs ($p < 0.81$) or logs ($p < 0.57$).

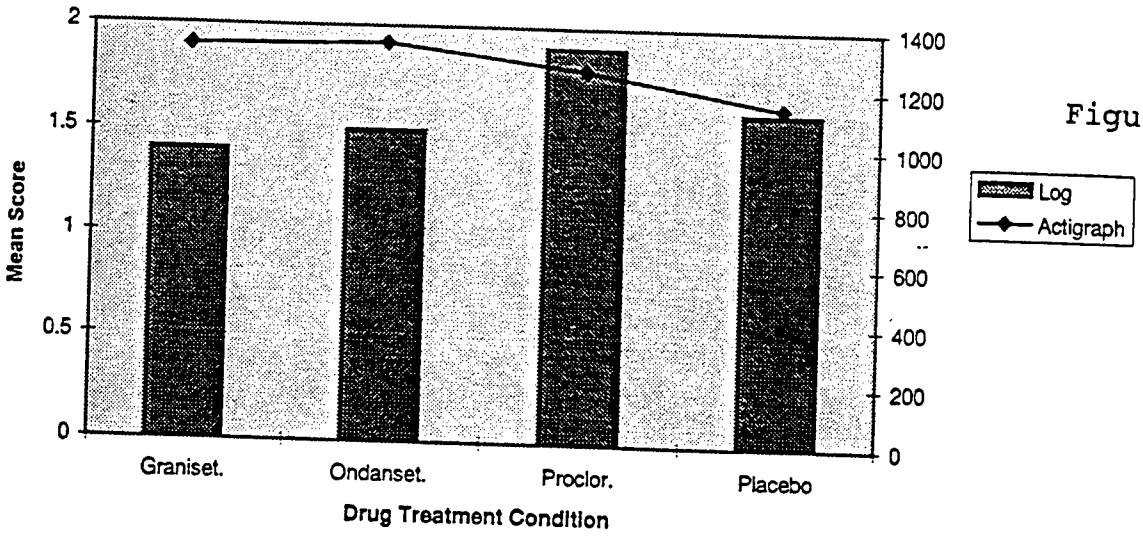

Figure 8

A z-transformation of the scored sleep duration scores revealed that the correlation between log sleep and actigraph sleep for both pre and post session scores was significant ($p < 0.003$).

Discussion

No differences were found between drugs in subjective fatigue and oral temperature during a session. There were no differences in the test compounds in pre-session sleep duration and quality nor in post session sleep duration and quality. This provides evidence that the lack of an effect on cognitive scores associated with the test drugs, Kytril and Zofran, are real and not due to differential sleep before a session. The lack of effects post session on sleep duration and quality indicates that Kytril and Zofran will not interfere with crew rest. This report provides further evidence that Kytril and Zofran are safe anti-emetic compounds that can be used prophylactically by crews without compromising their cognitive ability.

The graphs comparing actigraph scores and log scores reveal that the actigraphs consistently score more sleep than the logs. This could be the result of the logs half-hour resolution compared to the minute assessment of the actigraph. The larger scores for the actigraph may also be limb inactivity which would be represented as 'phantom sleep' incorrectly scored as actigraph sleep, hence inflating the sleep times. However, the actigraph scores are closer to the 7-8 hours of sleep that people normally get and may be a more accurate assessment of sleep duration. The significant

correlation between actigraphs and logs suggests that both are adequate.

The actigraph seems to be an acceptable measure by itself of sleep/wake cycles and some indication of sleep quality. The logs have always been considered acceptable measures but they may be too subjective to use by themselves and are demanding of the subjects (and the investigators) time. Both are good techniques but the logs seem stronger with the actigraphs than the actigraphs do with the logs.

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Appendix 1. A log sheet for 4 days of data. Subjects would indicate subjective fatigue and oral temperature and sleep quality and duration under the appropriate time for each day.

TIME OF DAY (LOCAL)

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SLEEP/NAP TIME																								
SUBJECTIVE FATIGUE																								
Temperature																								

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SLEEP/NAP TIME																								
SUBJECTIVE FATIGUE																								
Temperature																								

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SLEEP/NAP TIME																								
SUBJECTIVE FATIGUE																								
Temperature																								

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SLEEP/NAP TIME																								
SUBJECTIVE FATIGUE																								
Temperature																								

<u>SUBJECTIVE FATIGUE</u>

Write the number of the statement which describes how you feel RIGHT NOW.

1 = Fully alert, Wide Awake, Very Peppy
2 = Very lively, Responsive, Not at Peak
3 = Okay, Somewhat Fresh
4 = A Little Tired, Less Than Fresh
5 = Moderately Let Down
6 = Extremely Tired
7 = Completely Exhausted, Unable to function

Indicate Periods of Sleep of Sleep to nearest 1/2 hour by: S-----S at start and end of sleep period.

UPON AWAKENING, INDICATE SLEEP QUALITY WITH :

+ TO INDICATE THAT YOU SLEPT BETTER THAN NORMAL
= TO INDICATE THAT YOU SLEPT ABOUT THE SAME AS NORMAL
- TO INDICATE THAT YOU SLEPT WORSE THAN NORMAL

FUEL SPILL IDENTIFICATION BY SOLID PHASE MICROEXRACTION

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Armstrong Laboratory

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FUEL SPILL IDENTIFICATION BY SOLID PHASE MICROEXTRACTION

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Abstract

In order to determine the differences in gas chromatograph profiles of different jet fuels, six different types of neat, or pure, fuels were tested by way of solid phase microextraction. These fuel types were JP-4, JETA, JP-5, JP-8, JP-7, and JPTS. Many samples of each type of fuel were analyzed by way of headspace with the SPME fiber. These fuels were then run through the GC to obtain a profile of each. The profiles from each fuel type were compared, and a common profile of each fuel was obtained. Using this information, a sample from a highly contaminated well was taken and sampled on the GC. Its profile proved very similar to that of a JP-4 fuel, with slight differences due to weathering. This indicates that it is indeed possible to determine a fuel type by way of solid phase microextraction.

FUEL SPILL IDENTIFICATION BY SOLID PHASE MICROEXTRACTION

Michael R. Wilson

Introduction

The identification of a fuel is very important in the case of a spill in the environment. This is because there are several types of fuels used, and, in the case of an area with different fuels stored, indicating the fuel causing the spill allows one to fix the problem more quickly. Therefore, it is of utmost importance to determine the fuel type in order to fix the problem. The sooner the fuel is identified, the sooner it can be cleaned up. Equally important is the issue of who is at fault. When a fuel is spilled, the guilty party must pay for damages and clean-up. With this in mind, it was decided to determine if fuel spill identification is possible by way of solid phase microextraction.

SPME Background

Solid phase microextraction, or SPME, is a means of sampling organic compounds from environmental samples. It uses a fused silica fiber coated with a polymeric compound, attached to a syringe assembly, as shown in Figure 1.[2,3] The fiber is protected by the syringe needle, and attached to a plunger.[4] When the plunger is depressed, the fiber is exposed.

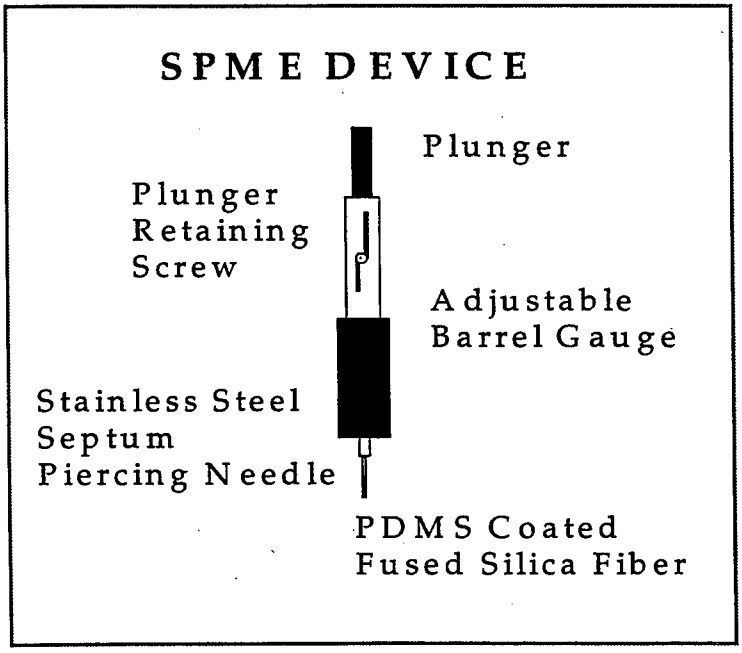


Figure 1. SPME Device.

Sampling is conducted by inserting the needle into a vial containing the sample, then depressing the plunger to expose the fiber. Once exposed, the polymer coating absorbs the molecules of the organic compounds, as illustrated in Figure 2. Following the sampling period, the fiber is retracted by releasing the plunger. The SPME device is then transfered to the injection port of a gas chromatograph(GC). The fiber is extended into the injection port exposing the polymeric coating and releasing the sorbed molecules, as shown in Figure 3, into the carrier gas, which carries them into the column for separation and analysis. The GC then records peaks caused by the organic compounds separated by the column.[1,2]

SPME/GC was originally proposed for the analysis of organic contaminants in water. Headspace analyses have also been reported for environmental contaminants in water [1] and for volatile flavor components.[4,5] This series of experiments explores the potential use of an SPME sampling device as a solvent free technique in the qualitative analysis of fuels.

Methodology

In order to determine a common profile for each fuel, many 100 ul samples of each fuel (JP-4, JETA, JP-7, JPTS, JP-5, and JP-8) were diluted in 900 ul methylene chloride and shot through the GC. It was noted that each fuel had characteristics that could possibly act as fingerprints for identification in the event of a fuel spill. The results of these preliminary tests were recorded for later examination.

Also, fuel mixtures were prepared. Binary mixtures ranging from 10%/90% to 90%/10% were made in fuel combinations such as JP-7/JP-8, JETA/JP-5, JP-4/JETA, JP-5/JP-8, etc. Each was tested using the dilute and shoot method.

It is important to note the GC conditions for each of these tests. In the dilute and shoot runs, the conditions were as follows: The initial temperature of the runs was 60°C. That temperature was held for 0.34 minutes. The temperature was then raised to 270°C at a rate of 18 deg/min, for a total run time of 12 minutes. However, for the next set of tests, using the SPME process, a new GC method was required. The run rate was slowed from 18 to 10 deg/min. Also, the initial temperature and initial time were changed, from 60°C to 40°C, and 0.34 minutes to 3.00 minutes. In both cases, the final temperature was not sustained.

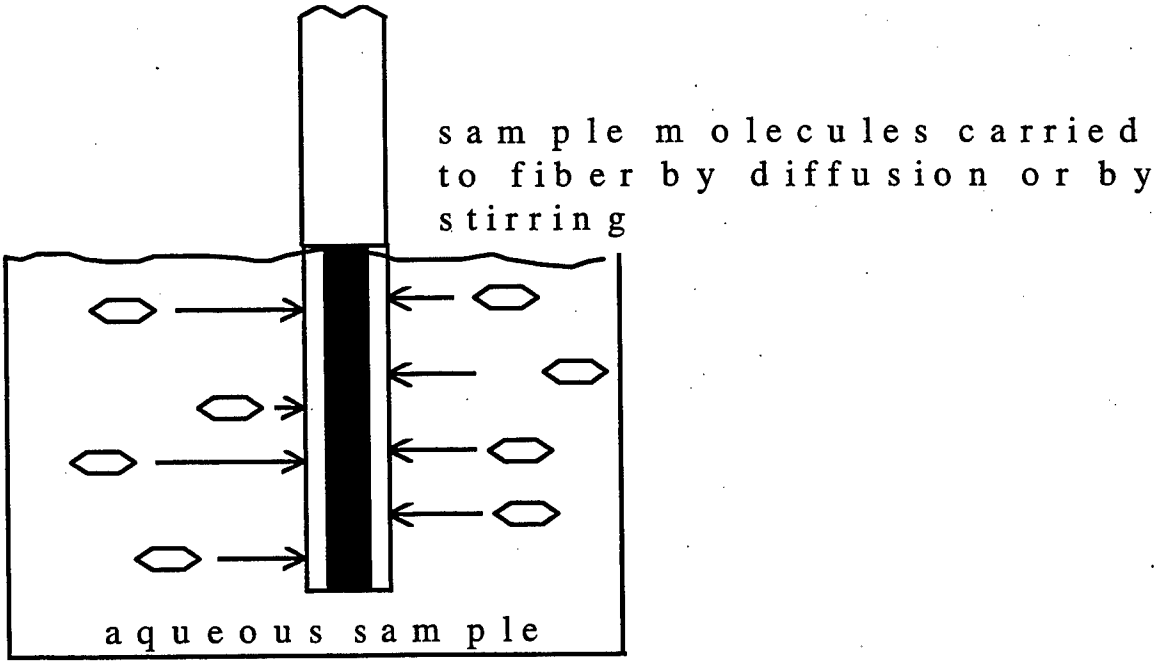


Figure 2. Sampling/Sorption Process in SPME.

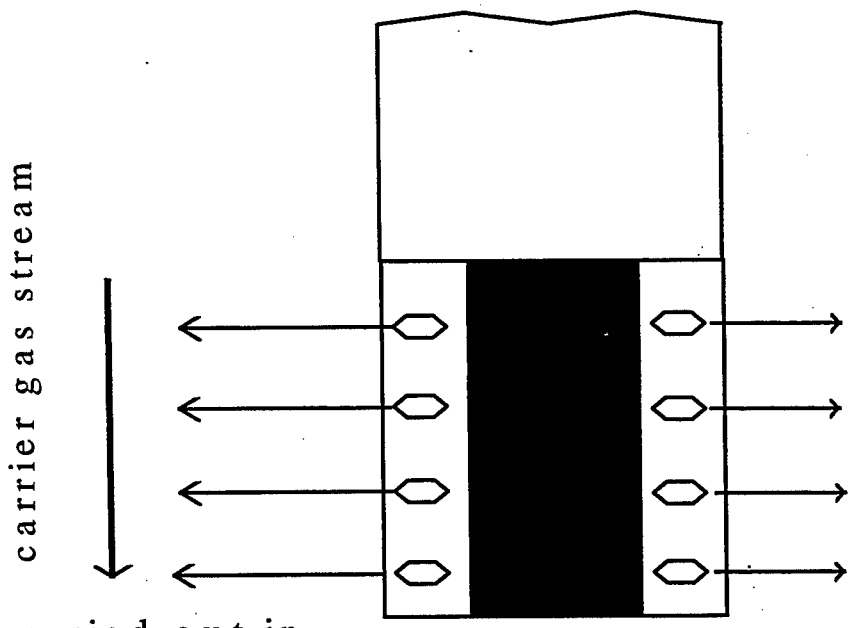


Figure 3. Desoption/Injection Process in SPME.

The same samples were then to be tested using the SPME device. The fiber was exposed to a headspace, that is to say it was exposed to the air above the fuel in the vial, for a length of time. It was

important to determine the most advantageous sampling time, so trials of a common fuel were run with sampling times of 1, 2, 3, 5, 7 , 10, 12, 15, 17, 20, and 25 minutes. It was determined that there was little variation between each trial, so the 10 minute sampling time was chosen for the experiment. This is because the retention times of key ingredients, such as benzene, toluene, and ethylbenzene, were easily distinguished using the 10 minute sampling time.

Using the 10 minute sample time, each fuel previously tested was tested using the SPME technique. They were then run on the GC, and the profiles of each were then compared to those of the dilute and shoot method. By gaining adequate profiles of each fuel type it was then determined that each fuel type had noticeable distinctions in its profile. This information allowed us to begin the next stage of the experiment.

Early in the summer, a sample of fuel and water was taken from a highly contaminated well at Tyndall AFB. These samples were stored at the lab refrigerator at 4oC, then tested using both the SPME and dilute and shoot techniques. The pure fuel was diluted in the same manner as the previous tests of this type, to be compared with those tests. The GC profile was then taken to observe peak heights and retention times in comparison to those of the neat, or pure, jet fuels earlier tested, in an attempt to determine the fuel type.

Results and Discussion

The GC profiles of common neat fuels tested by both the dilute and shoot and SPME techniques were compared. They appeared very similar in structure, although the retention times were different. This is due to the stated change in GC conditions. These results assured us that the profiles were consistent and reliable.

The profiles of the neat fuels using the SPME process were compared with those of the same type of fuel to determine characteristics for each fuel type that could act as fingerprints. It was determined that the JP-4 was more volatile than the other fuels. Variations were also noted between the other fuel types. An example of each fuel type is shown in Figure 4.

These profiles were then used to attempt to identify the well sample. It was determined that the sample had the characteristics of a JP-4 fuel. Its retention times mirrored those of a known JP-4 fuel. However, as seen in Figure 5, the earlier peaks do not match in terms of height. The sample appears to be JP-4 fuel which has lost a portion of its more volatile components. The lower volatile content is due to weathering. Weathering is described as any process which can change the composition of a spilled fuel in the environment.

The preliminary experiments proved that it was possible to determine profile characteristics of each fuel type. It was then proved that it was possible to distinguish between fuel types by SPME and GC profiles. By comparing the GC profile of the known JP-4 fuel with that of the well sample, it was proven that it was possible to identify characteristics of an unknown sample with those of a known fuel type. These findings led to the conclusion that it is possible to identify the type of a fuel spill by way of solid phase microextraction.

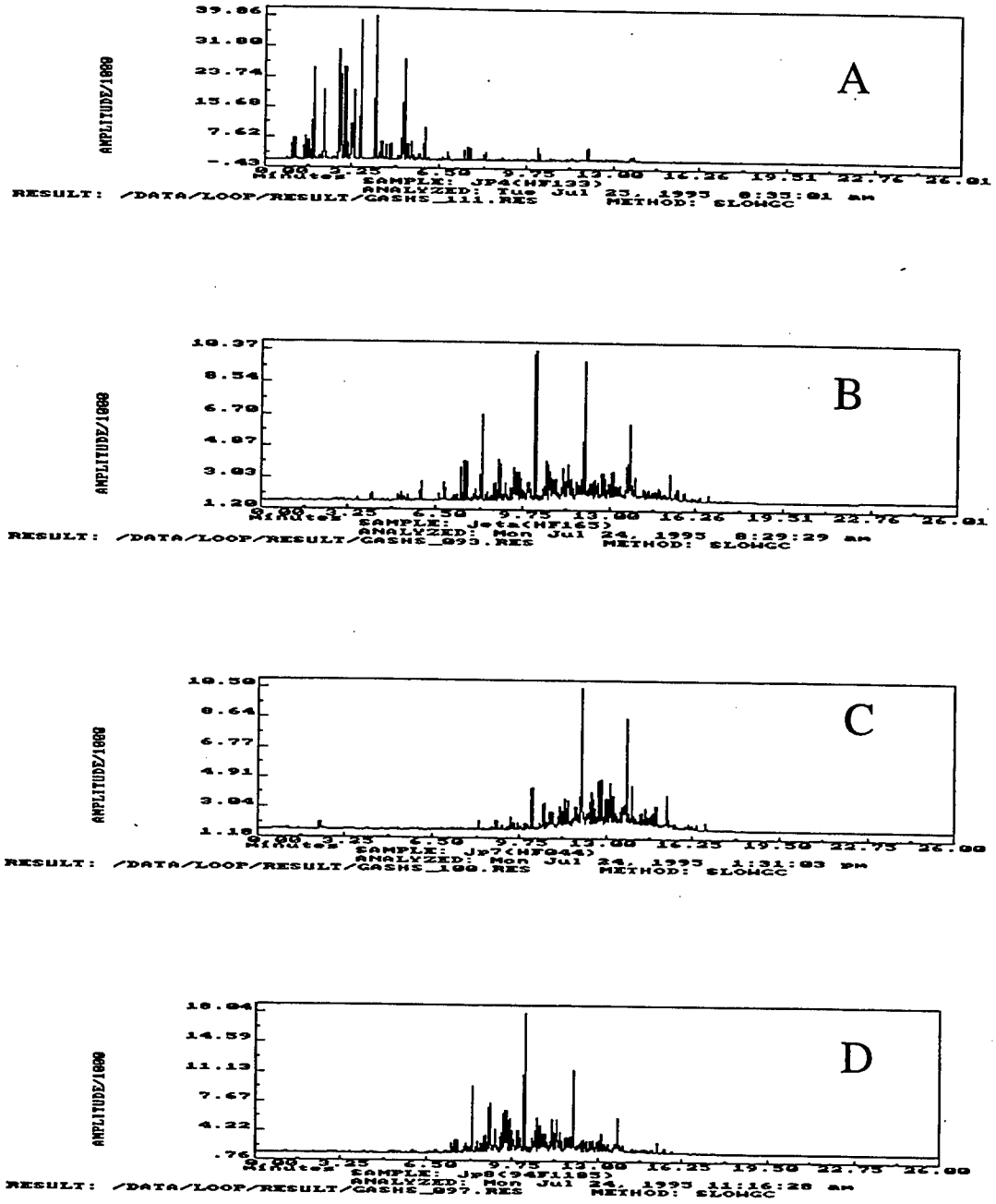
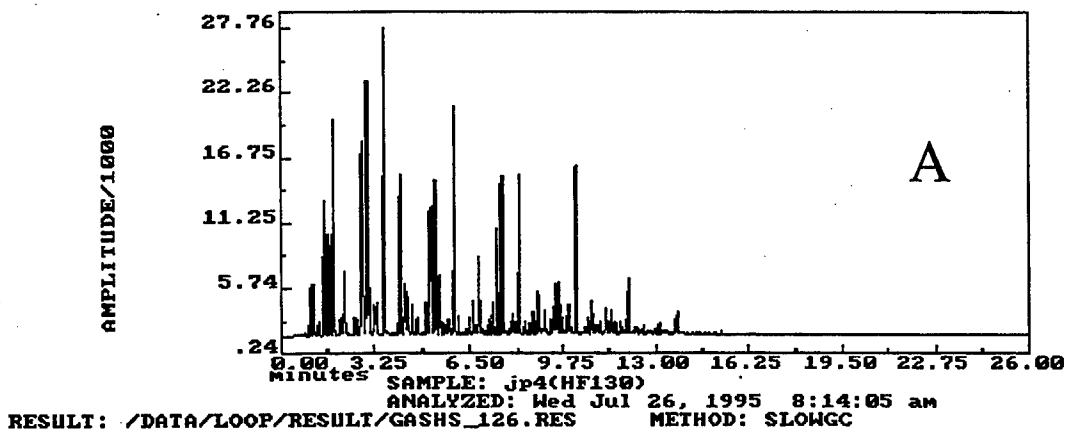


Figure 4. GC Profiles of Neat Jet Fuels Headspace-SPME/GC, A: JP-4, B: Jet-A, C: JP-7, D: JP-8.



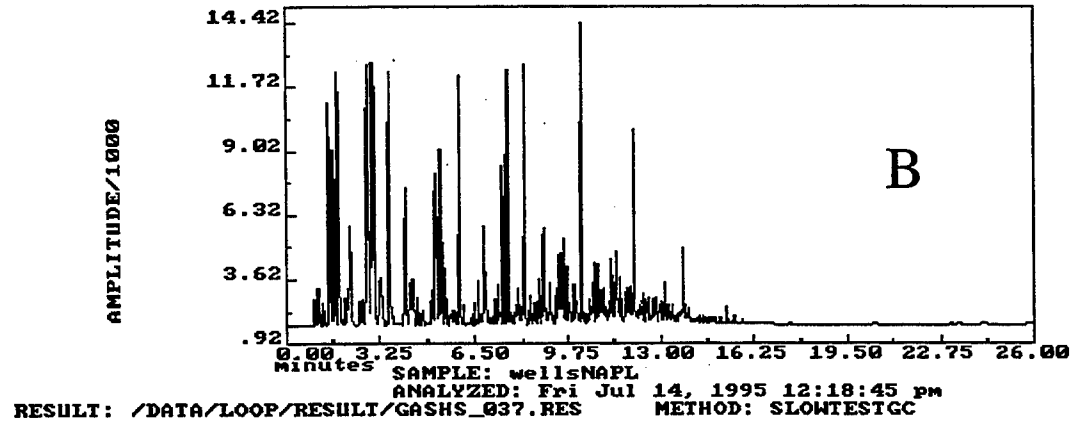


Figure 5. Comparison of Neat JP-4 and Recovered Product from Monitoring Well, by Headspace-SPME/GC.

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PART I. NARCOTIZATION OF TUNICATES

and

PART II. TUNICATES: REGENERATION OF SIPHONS

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Final Report for:

High School Apprentice Program

Armstrong Laboratory

Sponsored by:

Air Force Office of Scientific Research

Tyndall Air Force Base

and

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PART I

NARCOTIZATION OF TUNICATES

Michele Wisdahl

Port St. Joe High School

Abstract

Tunicates must be narcotized prior to preservation in order properly to prepare them for dissection and identification. Species react differently to anesthetics that have been reported in the literature. Tunicates were subjected to tricane methane sulfonate (MS-222), chloral hydrate, magnesium sulfate, menthol crystals and potassium chloride to determine which, if any, would best narcotize Styela plicata and Molgula occidentalis. The most efficacious narcotization procedure was the use of tricane methane sulfonate followed by injections of formalin into the siphons of the test individual.

PART I

NARCOTIZATION OF TUNICATES

Michele Wisdahl

Introduction

Tunicates are sessile marine invertebrates that live throughout the world, at all depths. They are benthic filter feeders possessing two siphons. The buccal siphon draws in water which, with its included plankton and seston, is filtered through the pharyngeal basket where both food and oxygen are extracted. Filtered water, gametes and fecal matter exit through the atrial siphon. The periodic squirting of water from the siphons, often in response to environmental disturbances, gave rise to the colloquial epithet, "sea squirt", for sessile tunicates.

Tunicates must be dissected in order to be properly identified. However, if a tunicate dies with its siphons contracted, as is usually the case, the preservative does not quickly reach the visceral tissues, and the specimen is useless in the identification process. Clearly, tunicates need to be narcotized before preservation if the animal is to be used for identification purposes.

Methodology

A variety of known invertebrate and vertebrate narcotizing agents were tested on the tunicates, Styela plicata and Molgula

occidentalis. Both are common species in St. Andrew Sound located near Tyndall Air Force Base.

The first experiment placed two Styela plicata in six 1120 ml aquariums at 29 degrees celsius water temperature (Appendix 1). In each aquarium, a narcotizing agent was added in the following dosages: chloral hydrate (0.5 ml), menthol (10 crystals), tricane methane sulfonate (0.5 ml), magnesium sulfate (1 ml), potassium chloride (1 ml), and one control containing seawater only.

Results

A light touch to the tunic of a sea squirt causes the siphons to contract. However, after five minutes in the anesthesia, the tunicates in chloral hydrate, menthol, and magnesium sulfate demonstrated a slowed response to pressure near the siphons. The MS-222 tunicates did not respond to touch. Potassium chloride caused the animals to close their siphons before they could be tested for sensitivity. After another five minutes, the animals in MS-222 did not respond to probing of the inside siphon wall. When thirty minutes passed, the animals treated with MS-222 and menthol did not respond to stimulation inside the siphon. MS-222 and menthol seemed to be effective, but when test animals were placed in formalin their siphons contracted.

A second experiment placed Styela plicata in a combination of narcotizing agents: chloral hydrate (.2 grams)/tricane methane sulfonate (.212 grams), and chloral hydrate (.2796 grams)/ menthol (.2454). After fifteen minutes, the animals in chloral hydrate/MS-222 displayed a slowed response to a light touch near the siphon. Twenty minutes later, the tunicates in chloral hydrate/menthol responded normally. The tunicates in chloral hydrate/MS-222 contracted when the probe touched the inside siphon wall (Appendix 2).

Conclusions

Additional experimenting (Appendix 3 & 4) developed a procedure for narcotizing Styela plicata and Molgula occidentalis. Approximately .112 grams of MS-222 must be added to every liter of water. When the tunicate allows stimulation inside the siphons without contracting (roughly ten minutes), a syringe full of preservative should be injected into the siphons. The tunicate can be placed in the preservative fluid after injection.

PART II

TUNICATES: REGENERATION OF SIPHONS

Michele Wisdahl

Abstract

Skepticism of an article written by W.C. George on the regeneration of siphons in Styela plicata caused a similar experiment to be preformed. The buccal and atrial siphons were closed off using superglue and nylon line. Amazingly, twenty-four to thirty-six hours later, new siphons formed in between the buccal and atrial siphons.

PART II

TUNICATES: REGENERATION OF SIPHONS

Michele Wisdahl

Introduction

"If one experimentally closes either of the siphon openings of the tunicate, Styela plicata, the animal exhibits a remarkable adaptive response. New siphon openings are quickly formed, and the animal resumes normal physiological activity."[1] When Dr. Collard, my mentor, ran across this statement, he expressed extreme skepticism towards regeneration in Styela plicata. To determine the possibility of regeneration, the experiment was duplicated using similar conditions.

Methodology

Nine aquariums, filled with six animals each, were acclimated to a lab temperature of 21 degrees celsius. Adhesive cyanoacrylate (superglue) was used to close two of the tunicates siphons from each tank. Two tunicates were sutured shut with a hand needle and 4-1b nylon line. The remaining tunicates were placed in the aquariums as controls (Appendix 5). In aquariums one, two and three, the buccal siphons were closed. The atrial siphons were blocked in tanks four, five and six, and in seven, eight and nine, both siphons were sutured or superglued. After two hours

[1]George, W.C. *The Formation of New Siphon Openings in the Tunicate, Styela Plicata.* 1937.

the unblocked siphons were open in the first six aquariums. In seven, eight and nine, the superglued tunicates seemed to be shriveling up.

Results

Between twenty-four and thirty-six hours later, the sutured buccal animals in one, two and three had grown new siphons. The new inhalant siphon appeared between the old buccal and atrial siphon. Some siphons had simply grown longer to bypass the sutures. The superglued animals were not as far along in siphon regeneration. Some had new siphons, but the lobes and lines of pigment were not formed. When pressure was applied to a bubble located between the siphons, it burst and a new siphon was functional.

In four, five and six, the results were similar. The new atrial siphon was located in between the buccal and old atrial siphon. Sometimes, the new siphon was formed using a hole created by the needle.

Like the tunicates in one, two and three, the sutured test animals in tanks seven, eight, and nine often grew longer to circumvent the deleterious suture. The new siphons were located between the old buccal and old atrial siphons. Most animals had at least one bubble on their tunic. However, the double

superglued tunicates died before new siphons were completely formed.

Conclusions

Experimentally closing the siphon of a tunicate causes the animal to regenerate its closed siphon within thirty-six hours. Even if both are blocked, fully functional siphons with four lobes and lines of pigment will form between the buccal and atrial siphons.

Acknowledgements
I thank the following individuals and organizations at Tyndall Air Force Base, for providing support and encouragement during my summer research activities: my mentor, Dr. Sneed B. Collard, Director of Marine Biological Research; Dr. Jimmy C. Cornette, Chief, Environmental Research Division, Environics Directorate, Armstrong Lab; Col Neil Lamb, Environics Directorate, Armstrong Lab; Dwaine Fletcher Co.; Dr. Richard Brewer, Environmental Group Leader of ARI; James Bailey; Bob Nichols; Armstrong Laboratory Technical Information Center; Cadet Eric Greeson; RDL; and AFOSR.

APPENDIX 1

Tunicate Anesthesia #1

tunicates removed from:
rope #7 (38 removed)
blue B (15 removed)

Experimental Tunicate Information

number	length (in)		volume displacement (ml)		anesthesia treatment	dosage (1 ml vials)
1	1.5	3	10	40	chloral hydrate	0.5
2	1.75	3.5	20	55	dl-Menthol (10 crystals)	
3	1.75	3.25	15	55	MS-222	
4	2	3	20	40	magnesium sulfate	
5	1.25	3	10	40	potassium chloride	
6	1.75	3.25	15	45		

Siphon Status

number	time	small	large	Treatment Administered (time)
1	1122	open	closed	1148
2	1122	closed	open	1150
3	1123	open	open	1147
4	1123	open	open	1145
5	1124	open	open	1145
6	1124	open	open	

aquaria volume: 1120 ml
water temperature (degrees celsius): 29

Response to Anesthesia Treatment

number	time	response
1	1156	slow response to probing near siphon
2	1156	slow response to probing near siphon
3	1154	no response to heavy probing near siphon
4	1154	slightly slower response to probing near siphon
5	1202	siphons closed
6	1154	normal response
1	1221	both completely closed off
2	1221	closes slowly with probing inside siphon
3	1221	not responding to probing inside siphon
4	1221	closes slowly with probing inside siphon
5	1221	both completely closed off
6	1221	normal response
2	1237	very slow response; closing with deep probing inside siphon
3	1237	no response to deep probing inside siphon

1	1254	little or no response to deep probing .
2	1254	no response to deep probing
3	1254	no response to deep probing; barnacles are normal
4	1254	slowing reponds to deep probing
5	1254	both siphons closed off
6	1254	normal response

APPENDIX 2

Tunicate Anesthesia #2

Experimental Tunicate Information

number	type	length (in)		volume displacement (ml)	
1	molgula	2.5	2.5	90	74
2	molgula	2.25	2.75	85	115
3	styela	1.5	3	20	42.5
4	molgula	2.75	2.25	95	45
5	styela	2	2.75	10	42
6	molgula	2.75		62	
6	styela	3.25		45	

number	anesthesia treatment	dosage (gr)	treatment administered (time)
1	MS-222	0.1211	1143
2	chloral hydrate	0.5	1150
3	chloral hydrate	0.2	1147
3	MS-222	0.12	1147
4	dl-menthol	0.5075	1157
5	chloral hydrate	0.2796	1201
5	dl-menthol	0.2454	1201
6	control	0	1143

aquaria volume: 1120 ml
water temperature (degrees celsius): 22

Response to Anesthesia Treatment

number	time	response
1	1155	still responds to light touch; closes siphon
1	1205	closes slowly with light touch
2	1205	siphons closed
3	1206	very slow response to light touch
4	1207	closes slightly slower than normal to light touch
5	1207	siphons closed
6	1207	normal response

1	1216	closes slowly to medium touch
3	1216	closes after deep probing inside siphon
1	1227	injected molgula 1 with MS-222 mixture
1	1232	injected molgula is not responsive; molgula 2 still responds to heavy touch
2	1230	slow response to heavy touch
4	1230	slow response to heavy touch
5	1230	responds normally to heavy touch
6	1230	normal response
4	1246	still responsive to heavy touch
1	1257	injected molgula 1 with MS-222 again; put in jar with formalin; siphons open
4	1337	injected with formalin; siphons closed off

APPENDIX 3

Tunicate Anesthesia #3

Experimental Tunicate Information

number	volume displacement of 2 (ml)	anesthesia treatment	dosage (gr)
1	47	MS-222	0.1254
2	45	MS-222	0.2534
3	60	MS-222	0.3732
4	50	MS-222	0.5037

aquaria volume: 1000 ml
MS-222 administered: 1104

definitions

light touch- probe touches near siphon with little pressure
medium touch- probe touches siphon lobe with medium pressure
heavy touch-probe touches inside siphon with medium-heavy pressure

Response to Anesthesia Treatment

number	time	response
1	1106	responds to light touch
2	1106	responds slowly to light touch
3	1106	responds slowly to light touch
4	1106	responds slowly to light touch
1	1107	responds slowly to light touch
2	1107	responds very slowly to light touch
3	1107	does not respond to light touch
4	1107	does not respond to light touch
1	1110	one closed off before probing; responds to medium touch
2	1110	not responsive to medium touch
3	1110	not responsive to medium touch
4	1110	one closed off before probing; not responsive to medium touch
1	1114	not responsive to heavy touch
2	1114	not responsive to heavy touch
3	1114	not responsive to heavy touch
4	1114	not responsive to heavy touch
1	1126	not responsive to heavy touch
2	1126	not responsive to heavy touch
3	1126	not responsive to heavy touch
4	1126	not responsive to heavy touch

preservative results (1339)

1 atrial open; siphons open

2 buccal open; siphons open
3 atrial open; siphons closed
4 siphons closed; siphons closed

APPENDIX 4

Tunicate Anesthesia #4

Experimental Tunicate Information

number	displacement of 2 (ml)	anesthesia treatment	dosage (gr)	time administered
1	60	chloral hydrate	0.252	1112
2	70	chloral hydrate	0.505	1111
3	65	chloral hydrate	0.756	1109
4	50	chloral hydrate	1	1107
5	50	control		

aquaria volume: 1000 ml

definitions

light touch- probe touches near siphon with little pressure
medium touch- probe touches siphon lobe with medium pressure
heavy touch-probe touches inside siphon with medium-heavy pressure

number	time	response	number	time	response
1	1114	responsive to light touch	1	1115	responsive to light touch
2	1114	responsive to light touch	2	1115	responsive to light touch
3	1114	responsive to light touch	3	1115	responsive to light touch
4	1114	responsive to light touch	4	1115	responsive to light touch
1	1116	closed siphons	1	1117	responsive to light touch
2	1116	closed siphons	2	1117	responsive to light touch
3	1116	closed siphons	3	1117	closed siphons
4	1116	closed siphons	4	1117	closed siphons
1	1123	responsive to light touch	1	1133	responsive to light touch
2	1123	responsive to light touch	2	1133	responsive to light touch
3	1123	responsive to light touch	3	1133	responsive to light touch
4	1123	responsive to light touch	4	1133	responsive to light touch
1	1153	responsive to light touch	1	1233	slightly slowed response to medium touch
2	1153	responsive to light touch	2	1233	slightly slowed response to medium touch
3	1153	responsive to light touch	3	1233	slightly slowed response to medium touch
4	1153	responsive to light touch	4	1233	slightly slowed response to medium touch

APPENDIX 5

Siphon Regeneration

Experimental Tunicate Information

number	volume displacement of 6 (ml)	treatment
1	50	superglue buccal (2);suture buccal (2);control (2)
2	50	superglue buccal (2);suture buccal (2);control (2)
3	100	superglue buccal (2);suture buccal (2);control (2)
4	90	superglue atrial (2);suture atrial (2); control (2)
5	90	superglue atrial (2);suture atrial (2); control (2)
6	60	superglue atrial (2);suture atrial (2); control (2)
7	100	superglue both (2); suture both (2); control (2)
8	100	superglue both (2); suture both (2); control (2)
9	100	superglue both (2); suture both (2); control (2)

superglue materials: adhesive cyanoacrylate MIL-A-46050C
suture materials: nylon 4 lb line (dipped in alcohol)
singer hand needle

date of procedure: 6/16/95

sg-superglued a-atrial
s-sutured b-buccal

Results date of results: 6/19/95

number	type	description
1	sg#1	new siphon, between a & b; soft below a (enzymes?)
	sg#2	new siphon, between a & b; siphon not as prominent as s
	s#1	new siphon, between a & b; pigment gone out of original
	s#2	new siphon, between a & b; soft below a (enzymes?)
	controls	one is hard, dead tissue (?)
2	sg#1	bubble between a & b; new siphon (?)
	sg#2	new siphon, between a & b; new lines of pigment
	s#1	new siphon, formed under suture
	s#2	rejected suture (?); suture is missing
	controls	one is hard, dead tissue (?)
3	sg#1	new siphon, between a & b
	sg#2	new siphon, between a & b
	s#1	no new siphon; extended old
	s#2	no new siphon; extended old
	controls	one has soft tissue all over
4	sg#1	new siphon, between a & b; not prominent, squirting
	sg#2	can't tell
	s#1	soft tissue around suture; can't tell

	s#2	can't tell
	controls	normal
5	sg#1	new siphon, between a & b; almost under sg
	sg#2	new siphon, between a & b
	s#1	new siphon, formed under suture
	s#2	new siphon, between a & b
	controls	normal
6	sg#1	new siphon, between a & b
	sg#2	new siphon, between a & b
	s#1	siphon extended; suture loosened
	s#2	new siphon; under suture
	controls	normal
7	sg#1	a-bubble underneath;b-new siphon between a & b
	sg#2	dying
	s#1	a-new siphon between a & b;b-extended siphon
	s#2	a-extended siphon;b-extended siphon
	controls	normal
8	sg#1	forming new a & b; dying
	sg#2	a-new siphon under glue; b-can't tell
	s#1	a-extended;b-loosened suture
	s#2	a-extended siphon;b-used two of old lobes to form new, squirting
	controls	normal
9	sg#1	dying
	sg#2	a-no new siphon;b-bubble
	s#1	a-extended siphon;b-can
	s#2	a-can't tell;b-new siphon, between a & b
	controls	normal

dead: 7sg#2, 8sg#1, 8sg#2, 9sg#1

Pre- and Post-G Strength Evaluation

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

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and

Armstrong Laboratory

September 1995

PRE- AND POST-G STRENGTH EVALUATION

Eric Yu
Fairborn High School

Abstract

Strength capabilities of fifteen men and fifteen women in operating aircraft cockpit controls before and after exposure to fighter combat-equivalent G levels were analyzed. Maximum strength exertions of non-fatigued subjects on rudder pedals, flight sticks and wheels, and side and center ejection handles in an aircraft cockpit test station were recorded as baseline. Subjects remained awake for thirty hours prior to flying an F-16 combat engagement simulation in a multi-axis centrifuge. Maximum strength exertions were immediately reevaluated following fatigue and exposure to a high-G environment. At the conclusion of the author's research tour, only the baseline data had been collected.

PRE- AND POST-G STRENGTH EVALUATION

Eric Yu

Introduction

Prior to 1993 all U.S. fighter cockpits were designed to meet the physical characteristics and capabilities of male pilots. With the rescinding of the Combat Exclusion Ban, questions of cockpit safety for women arose. Resistance forces in aircraft controls and ejection handles were established around the amount of force that a male pilot could generate while maintaining proper control of the aircraft. Because the physical strength of males is generally greater than females, the resistance in pilot controls may create difficulties for female pilots. Aircraft cockpit designs must address the safety issues for women.

Discussion of Problem

Several studies have been conducted to determine the levels of control resistance accommodating the strength of women and men (1, 2, 3). However, the studies comprised test subjects in normal, everyday strength levels. They did not address the flight conditions that prevent the pilot from exerting maximum effort upon the controls. During combat pilots may become fatigued from anxiety, rapid respiratory reactions, and high-G straining maneuvers. Such extreme physical exertion reduces the maximum strength output of pilots on flight controls. Furthermore, if the aircraft or the pilot were injured, the pilot may not be able to generate enough strength to safely navigate the aircraft to safety or to operate the ejection handles.

The experiment was designed to provide a realistic analysis on strength output of male and female pilots experiencing fatigue after a high-G combat scenario.

Method

Subject Training

Fifteen male and fifteen female volunteers, who were between the ages of 20 and 40 and were deemed medically fit to ride a centrifuge, were trained in a full mockup of an F-16 cockpit. Test subjects were trained to read the information presented by the instrument panels and heads-up display, operate the throttle and air brakes, and perform low- and high-G flight maneuvers. Test subjects were led through twelve training levels, each level being a computer-generated simulation of the aircraft beginning at 10,000 feet and following another aircraft. Actual flight dynamics of the F-16 were incorporated into the simulation. Subjects were to track the aircraft through various maneuvers as accurately as possible, which became increasingly demanding with each additional level. The final levels of training also included a Surface-to-Air-Missile randomly fired from behind the test subject's aircraft, which compelled the subjects to execute evasive maneuvers to avoid the missile.

Subjects were trained to execute the high-G straining maneuver, the tensing of all arm, torso, abdomen, and leg muscles. A pressure of approximately 20 psi is exerted upon the lungs. The intra-thoracic and intra-abdominal pressure forces blood within the body to travel to the brain. This maneuver, in cooperation with a G-suit, prevents high Gz forces from pulling blood away from the brain and causing blackout.

Subjects were equipped with a flight suit, G-suit, and COMBAT EDGE oxygen mask and placed within the three-axis Dynamic Environment Simulator centrifuge. Subjects were trained to avoid blackout up to nine Gs.

Strength Measurement Device

Baseline strength data of the test subjects was obtained using a test device specifically constructed to measure maximum exertion on cockpit controls. A heavy steel frame supported an adjustable seat constructed to the specifications of an ACES II ejection seat. The seat also held both side and center ejection handles. The handles were linked to a spring, which produced resistance equivalent to the forces at the breakout point in actual aircraft ejection handles: 116 in-lbs in the side handles and 21 lbs in the center handle. The handles were lifted to the point of breakout equivalent in an ACES II ejection seat, where an arresting bar prevented excess movement of the handles. However, the load cell attached to the spring continued to measure additional forces exerted by the test subject. Only the side handles were used in the test, for the center handle could not be calibrated to produce an accurate reading.

A steel vertical column centered before the seat held a yoke with three cylindrical hand grips that represented both an aircraft control stick and a control wheel. The cylinders were covered by soft plastic to minimize grip loss. Although the control column did not move, load cells directly behind and to the right of the base of the control column measured strength exertion in the four cardinal directions of movement.

The pedal assembly represented the aircraft rudder control pedals. The pedals were positioned around a load cell, which measured opposing strength exertion of the pedals. If equal forces were exerted on both pedals, the load cell would report no force. The pedals also produced no movement.

The forces measured by the load cells were displayed by a machine that was placed behind the chair so that the test subject could not see the results. The display unit allowed the operator to select the portion of the strength testing device to be tested, to zero the unit, and to observe a three second average of the maximum amount of force generated. The display unit began calculating once the subject exerted a force on the strength testing device and signaled the end of the test by producing a beep.

A separate Compaq portable computer equipped with a measurement program was used to gather data from the ejection handles. The handles were zeroed by a transducer with a switch that exerted an electronic signal equivalent to 273.650 lbs. Any deviation from this value was adjusted in the transducer before conducting the test.

Strength Measurement

The test subject was tightly secured into the seat by a seat belt. The seat was moved forward so that the leg was bent at approximately a 140 degree angle when the feet were placed against the pedals. A protractor with a ruler extending from the zero degree origin was placed against the lateral condile of the leg to measure the leg angle. A specific test was selected from a predetermined, randomized order. With the subject's hands or feet away from the control column or the pedals, the test device operator zeroed the device

from the display unit. The operator ordered the subject to prepare and then to begin exerting force. The subject exerted a maximum amount of force in performing the test. A beep from the machine behind the chair signaled the subject to stop. When the ejection handles were being tested, the computer displayed the message, "test completed," and the operator informed the test subject to stop. Each test was conducted three times, with a thirty second recovery period allotted between tests to prevent fatigue.

Tests required the subjects to exert force upon the left rudder pedal and the right rudder pedal, to pull the center cylinder back toward the subject using the wrist muscles only (as in an F-16 force control stick), to grasp the outermost left and right cylinders and turn the wheel to the left, turn the wheel to the right, push the wheel forward, and pull the wheel backward, and to pull the side ejection handles with the left arm only, right arm only, and both arms.

When the four wheel tests were conducted, the seat was moved forward so that the subject's knees were almost touching the bottom of the cylinder yoke. The position allowed the subject to exert the most effective amount of force in controlling the wheel. The seat was moved back so that the leg was bent at 140 degrees after the wheel test was completed.

Pre- and post-G exposure strength measurements were recorded using this device and procedure.

G-Exposure

When all subjects had completed flight simulator training and baseline strength data had been collected, the subjects were forced to remain awake for

thirty hours before G-exposure.

Test subjects were fitted with their flight suit, G-suit, and COMBAT EDGE oxygen mask and secured within the cab of the centrifuge. The subjects flew a computer simulated engagement similar to their training missions. The centrifuge generated G levels in accordance to the levels produced by the flight maneuvers.

Following G-exposure the test subjects were immediately reevaluated with the strength testing device.

Results

Results were calculated from measurements recorded in Table 1. Baseline strength data suggests that males are generally stronger than females. On average, male leg strengths were 78.7% greater in the left leg and 60.0% greater in the right leg. Males averaged 43.0% stronger while pulling the flight stick backward. Operating the control wheel, males averaged 103.6% stronger while turning to the left, 96.4% stronger while turning to the right, 124.6% stronger while pushing the wheel forward, and 90.7% stronger while pulling the wheel backward. Males were 63.6% stronger in pulling the side left ejection handle, 51.4% stronger while pulling the side right ejection handle, and 73.1% stronger while pulling both side ejection handles.

Further data regarding the experiment was not gathered by the end of the author's research tour.

Conclusions

Test subjects had not completed the training flight sessions. No conclusions could be derived at the end of the author's research tour.

Table 1: Baseline Male and Female Strength Measurements

Name	Age	Sex	Height (inches)	Weight	Date of Experiment	Rudder Left (lbs)	Rudder Right (lbs)	Stick Back (lbs)	Wheel Left (lbs)	Wheel Right (lbs)	Wheel Forward (lbs)	Wheel Back (lbs)	Side Handle Left (lbs)	Side Handle Right (lbs)	Side Handle Both (lbs)
Subject 1	40	M	72.5	224	8/2/95	679	727	9	150	157	338	245	124	133	209
Subject 2	23	M	67	149	8/2/95	394	319	7	109	114	184	207	99	85	168
Subject 3	23	M	72.75	165	8/2/95	619	596	15	122	104	267	221	135	149	229
Subject 4	24	M	69	187	8/2/95	538	452	13	134	148	275	259	86	94	204
Subject 5	22	M	74.5	218	8/3/95	644	558	21	123	118	280	230	99	102	194
Subject 6	22	M			8/3/95	428	441	4	146	148	213	270	124	115	242
Subject 7	37	M	66	146	8/7/95	237	213	5	81	58	129	136	51	48	95
Subject 8	26	M	67.25	156	8/7/95	414	465	28	75	87	166	172	57	54	102
Subject 9	26	M	64	145	8/8/95	510	485	19	119	118	174	163	64	62	122
Subject 10	27	M	72	160	8/8/95	414	461	12	87	101	220	197	110	92	197
Subject 11	38	M	67.75	184											
Subject 12		M	69.5	147											
Subject 13		M	70	191											
Subject 14		M	72.75	203											
Subject 15		M	70.75	209											
Average		M				487.7	471.7	13.3	114.6	115.3	224.6	210	94.9	93.4	176.2
Subject 16	33	F	68	164	8/2/95	374	376	4	81	75	155	142	65	75	110
Subject 17	26	F	67.75	152	8/2/95	308	350	7	34	36	124	79	62	54	97
Subject 18	24	F	67.5	148	8/3/95	440	425	6	71	86	102	141	62	74	123
Subject 19	24	F	63.75	117	8/3/95	191	158	6	50	41	94	110	57	67	84
Subject 20	26	F	60	100	8/3/95	141	141	10	38	37	71	82	43	57	72
Subject 21	20	F			8/3/95	242	289	11	58	69	85	105	56	52	111
Subject 22	36	F	67	161	8/4/95	277	362	9	71	73	124	130	77	87	144
Subject 23	31	F	69.75	188	8/4/95	300	318	14	53	66	56	70	65	57	99
Subject 24	32	F	64.5	137	8/7/95	280	332	9	63	62	111	145	41	42	86
Subject 25	25	F	63	137	8/8/95	176	201	17	44	42	78	97	52	52	92
Subject 26		F	65	122											
Subject 27		F	65.75	157											
Subject 28		F	61.75	139											
Subject 29		F	64.75	138											
Subject 30		F													
Average		F				272.9	295.2	9.3	56.3	58.7	100	110.1	58	61.7	101.8

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A STUDY ON EEG COLLECTION AND INTERPRETATION

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A STUDY ON EEG COLLECTION AND INTERPRETATION

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Abstract

Experiments were done to identify subacute effects of multiple +Gz exposures. Studies on EEG instrumented male Sprague-Dawley rats were done using the Small Animal Centrifuge (SAC). These animals were exposed to increasing +Gz stress for two consecutive days. EEG data was then analyzed using Fast Fourier Transform (FFT), and Band Pass analysis. Analysis of EEG signal was needed to pin point the following: the approximate time consciousness was lost, baseline conditions, and helped in measuring prolonged G-LOC effects.

A STUDY ON EEG COLLECTION AND INTERPRETATION

Stephanie L. Zigmond

Introduction

The Air Force's interest in +Gz induced loss of consciousness, or G-LOC, has increased due to safety and medical concern for the pilots. G-LOC leaves a pilot vulnerable to the enemy and often results in the loss of the pilot and/or the aircraft. To prevent future accidents associated with G-LOC a small animal centrifuge was constructed for this purpose. Moreover, pilots were trained to engage in high +Gz maneuvers, especially under combat conditions. The aircraft is crafted to engage in such maneuvers, but the body can't withstand the maneuvers. The Air Force recognizes this as a serious problem and believes one of the answers may lie in understanding the mechanisms of G-LOC on the central nervous system. Experiments using an animal model and the Small Animal Centrifuge (SAC) have begun to shed light on brain EEG under high +Gz and possible protective measures for pilots.

Methodology

EEG SURGERY:

EEG data was obtained using instrumented male Sprague-Dawley rats, that were kept in the vivarium and brought to the laboratory as needed. The animals were anesthetized using 3% halothane. Surgical site was prepared by shaving the fur and cleaning the area with iodine. An incision was made in the scalp exposing the skull.

Three holes were drilled on the skull for electrode placements, two on the parietal bone for differential recording, and one hole on the frontal region for reference. Three metal screws attached to an insulated wire were used as electrodes. The electrodes were assembled into a plastic pedestal secured with cranioplastic cement and the incision was closed leaving the pedestal exposed. The animal was then allowed to recover prior to centrifugation. Several steps were taken to further characterized the biological effects of chronic instrumentation, such as testing for resistance between electrodes using a Fluke multimeter, assuring accurate EEG data.

RESTRAINT AND POSITIONING TECHNIQUES:

The animals were restrained in a custommade plexiglas restraint device, which held the animal's head and body at the correct +Gz alignment. The restraint device secured all limbs, while locking the head forward with a bite bar. Padding was placed for protection between the rat and the restraint bar. This positioning allowed the implanted EEG pedestal to be connected to a cable, which was then connected to the SAC through an amplifier. It was through this connection that the EEG signal was collected.

CENTRIFUGE EXPOSURE:

Each animal was exposed to nine +Gz forces for 65 seconds. For analysis purposes, the 65 seconds was broken down into 5 seconds of control data, 30 seconds of acceleration data and 30 seconds of recovery data.

EEG signals were generated, amplified and hardwired from the centrifuge to the Macintosh II FX via a pair of slip rings. The data was then stored in the Macintosh II FX until ready for further analysis. An EEG strip chart also served as hard copy of raw EEG data. When this data was ready to analyze, it was copied from the Macintosh II FX to the Macintosh Quadra 950 so that it could be analyzed with the Labview software.

DATA ANALYSIS:

All analysis was based on the time alignment procedure. This procedure identified and recorded the point of acceleration. The time alignment number was established by subtracting 5.0 secondsfrom the onset of acceleration. This number was used to calculate all other analyses from this point on. FFT was then performed on each rat for each of the nine +Gz levels for each day spent on the centrifuge. The FFT analysis categorgized the raw data according to four subcomponents; delta, theta, alpha, and beta. The raw data were broken down according to cycles per second or hertz in the following manner: delta 0-4 Hz, theta 5-8 Hz, alpha 9-13 Hz, and beta 14-30 Hz. Each of these power levels was indicative of different brain activities. For example, delta waves showed on the EEG when any survival system is in action, theta waves is associated with wakefulness, beta indicates action such as learning and thinking etc, and alpha waves appeared during visual activities. The other type of analysis performed was the Band Pass analysis. This was used to analyze and calculate peak thresholds and frequency bands. When EEG data was being calculated in Band Pass it used EEG 1, and EEG 2.

Band Pass analysis detected peak control in delta, theta, alpha, and beta. The analysis was made within a 1024 sampling rate for 65 seconds. EEG interpretation allowed the data to be imported and exported into a spreadsheet set up to be easier to calculate and transfer data in and out. The data was interpreted by the creation of graphs, programs, and charts. Graphs were made by importing all data through the use of the Macintosh Quadra 950. All graphs were made and saved within the DeltaGraph program. Most graphs were formatted to a nine plot graph. After the graphs were created they were saved and printed as examples of the resulting data.

RESULTS:

The observed patterns were based on the average of nine +Gz levels (N=11). For instance, during low +Gz levels (includes +Gz levels 0.5, 5, 10) delta and theta activities increased while alpha and beta activities remained normal. Another was at medium +Gz levels (includes 15, 17.5) where alpha and beta were silent, while theta shows a burst at half of the baseline value. Lastly at high +Gz levels (including 20, 22.5, 25) a large increase in delta and theta power appears with a silent alpha and beta leading to isoelectric signals. Recovery from high +Gz was associated with burst suppression. Burst suppression was a signal which cannot be defined as muscle spasm or a brain wave. An isoelectric signal was the state at which unconsciousness was definitive.

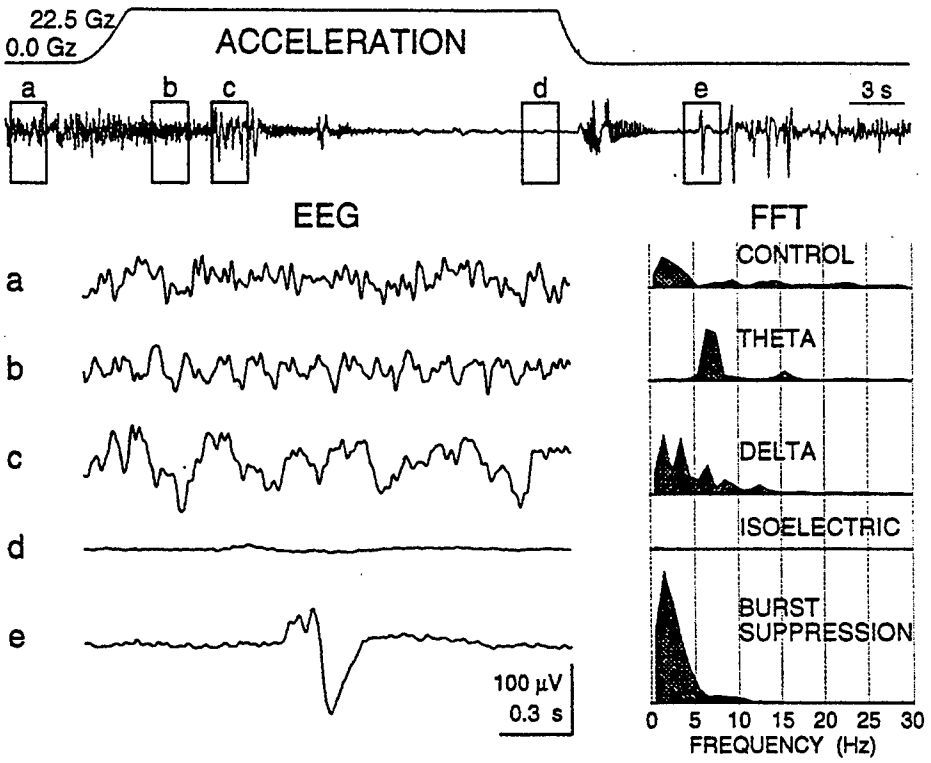

FIGURE 1:
This is an acceleration chart that gives examples of one rat at 22.5 Gz. Letters a-e correlate with each other, a- example of control data; b- example of theta signals; c- delta signals; d- isoelectric, e- example of burst suppression.

Reprentative of a 25 +Gz Band Pass analysis

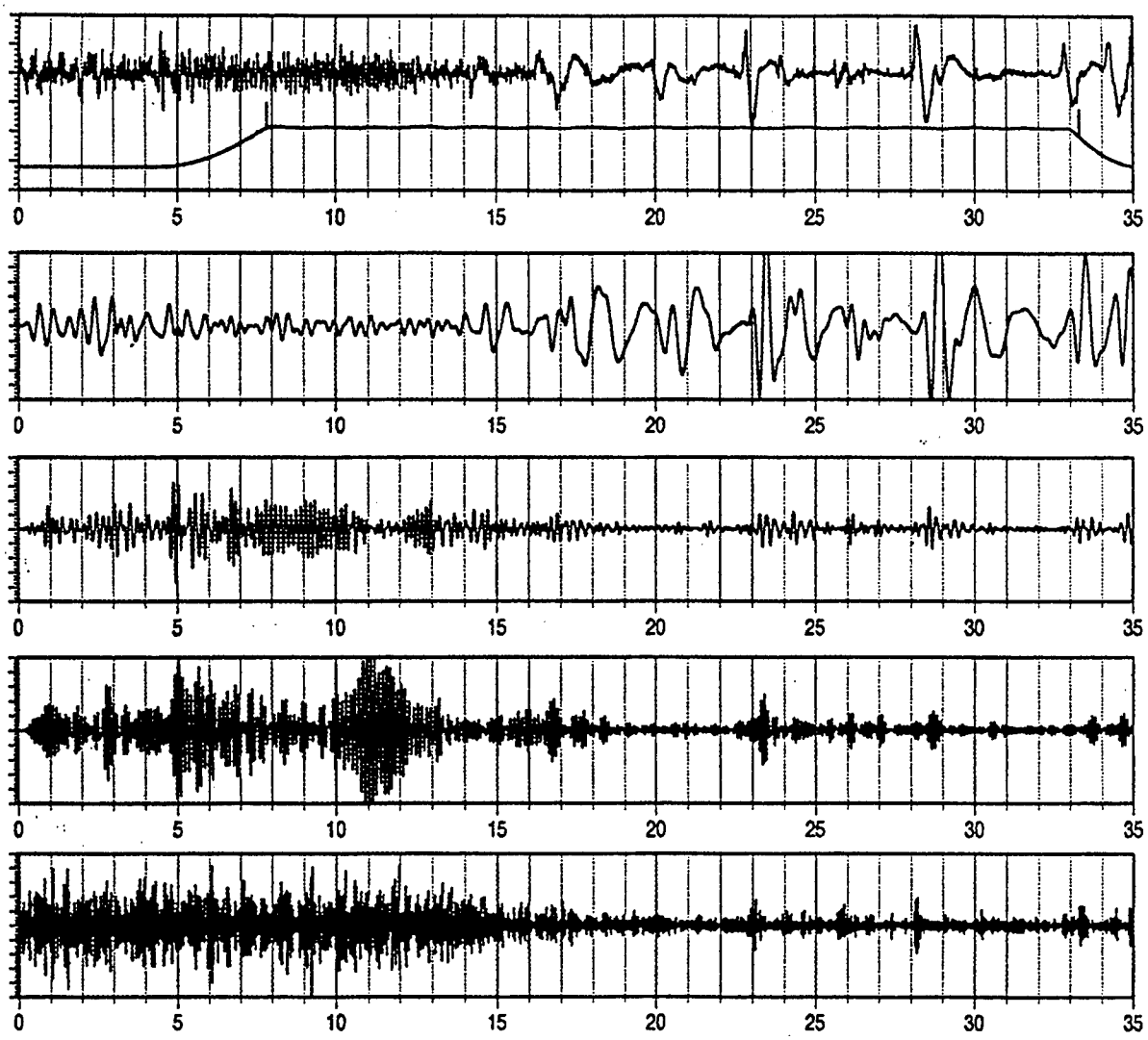

FIGURE 2:

An example of a Band Pass analysis graph of one rat at 25 +Gz. the first plot is raw the EEG, second plot is delta wave, the third is theta wave, fourth is alpha wave, fifth is beta wave.

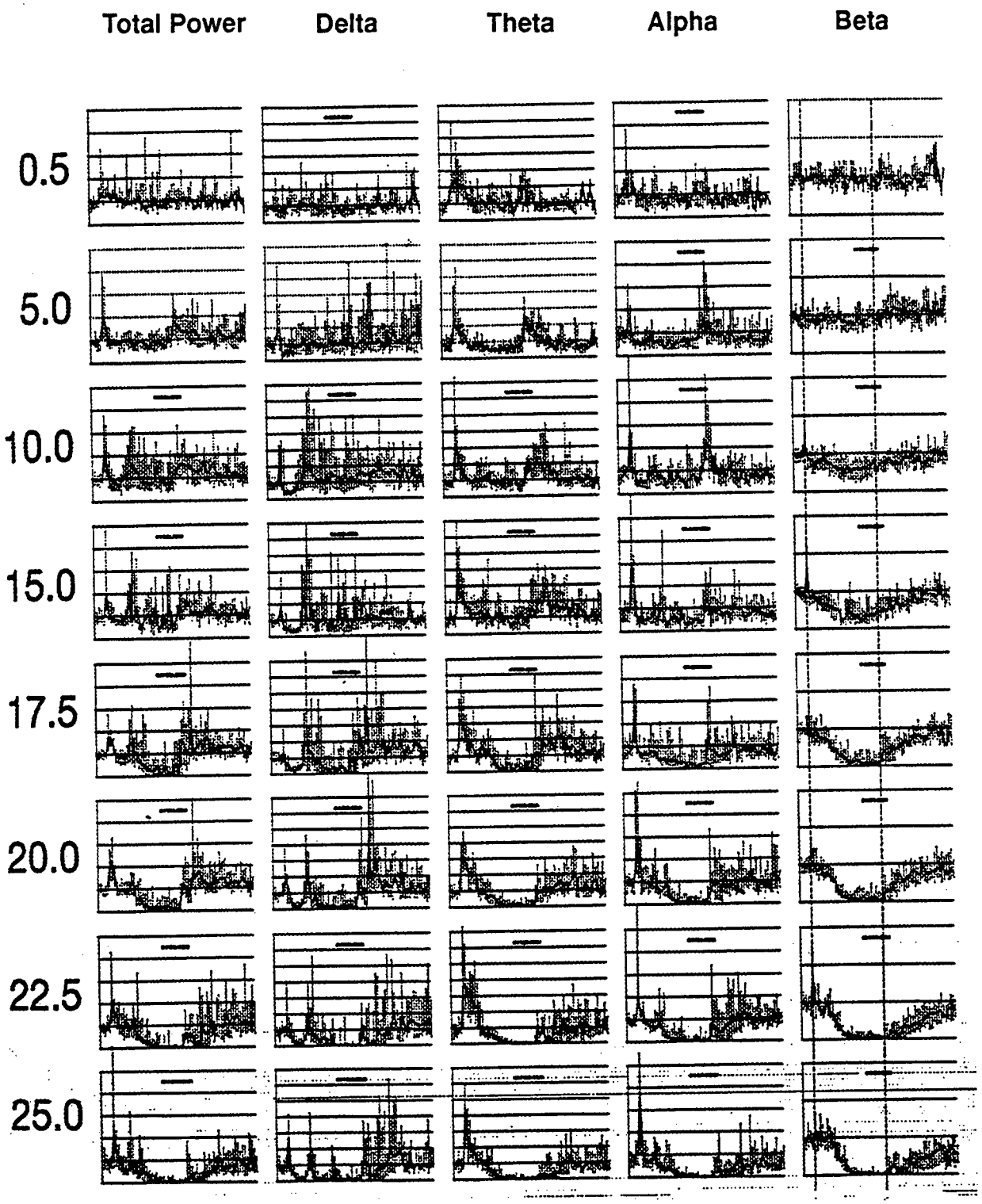

FIGURE 3:
This graph divides analyzed data into total power, delta, theta, alpha, and beta, at the nine +Gz levels

DISCUSSION AND CONCLUSION:

The conclusion of this experiment was that FFT analysis of an EEG provides a pattern correlating the nine +Gz levels to its subcomponents delta, theta, alpha, and beta. This study proved to be an adequate foundation for the research being done on unconciousness. One observation which can be made from this experiment was that the understanding of the effects of G-LOC on the central nervous system lies within the mechanisms of the brain and the analysis of those signals.